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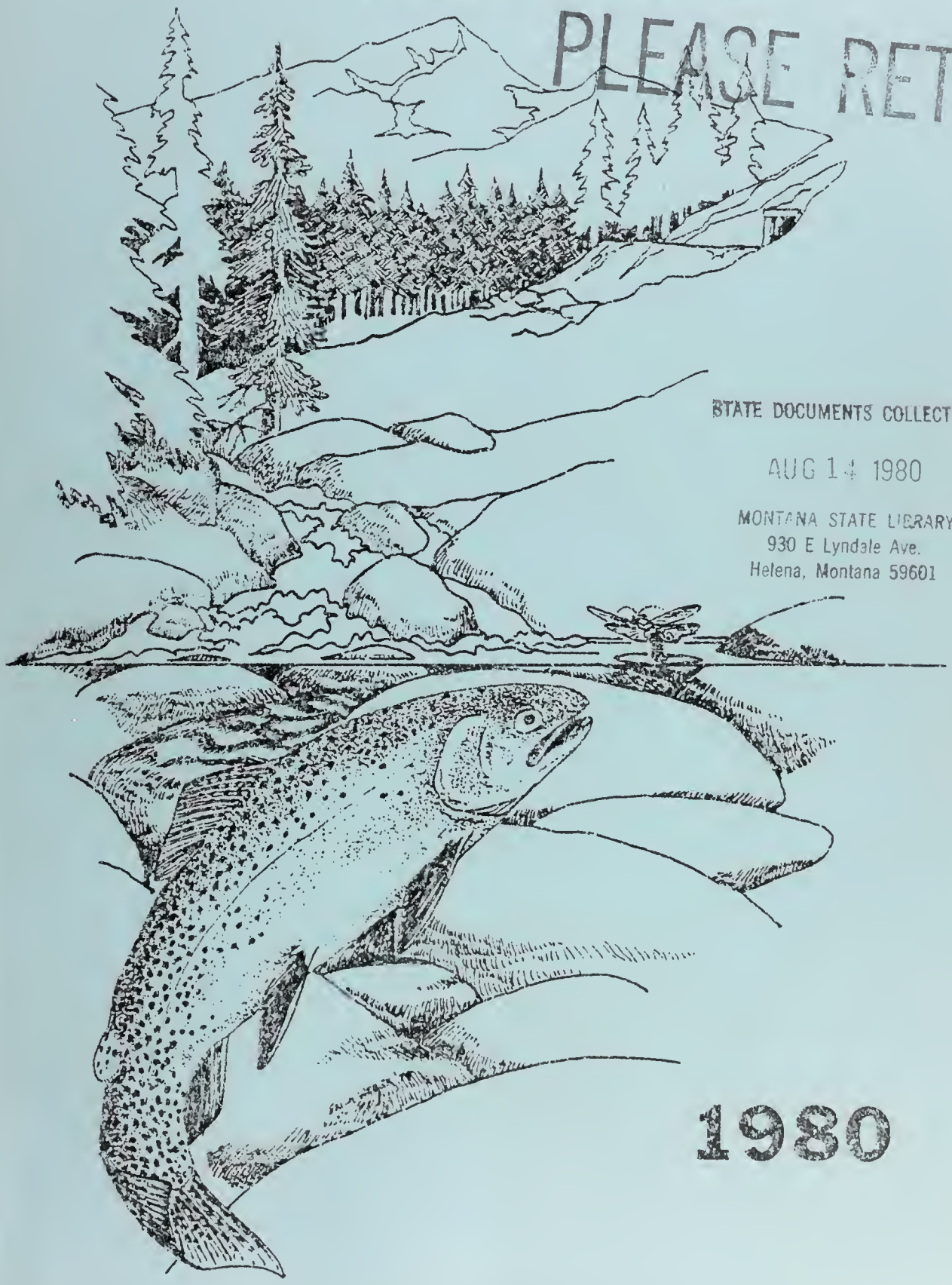

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WATER QUALITY IN MONTANA - 1980

Prepared for

Environmental Protection Agency
Region VIII
Denver, Colorado

Pursuant to The Clean Water Act
Section 305(b)

Prepared By

Water Quality Bureau
Environmental Science Division
Department of Health and Environmental Sciences

with assistance from

Montana EPA Office

June 13, 1980

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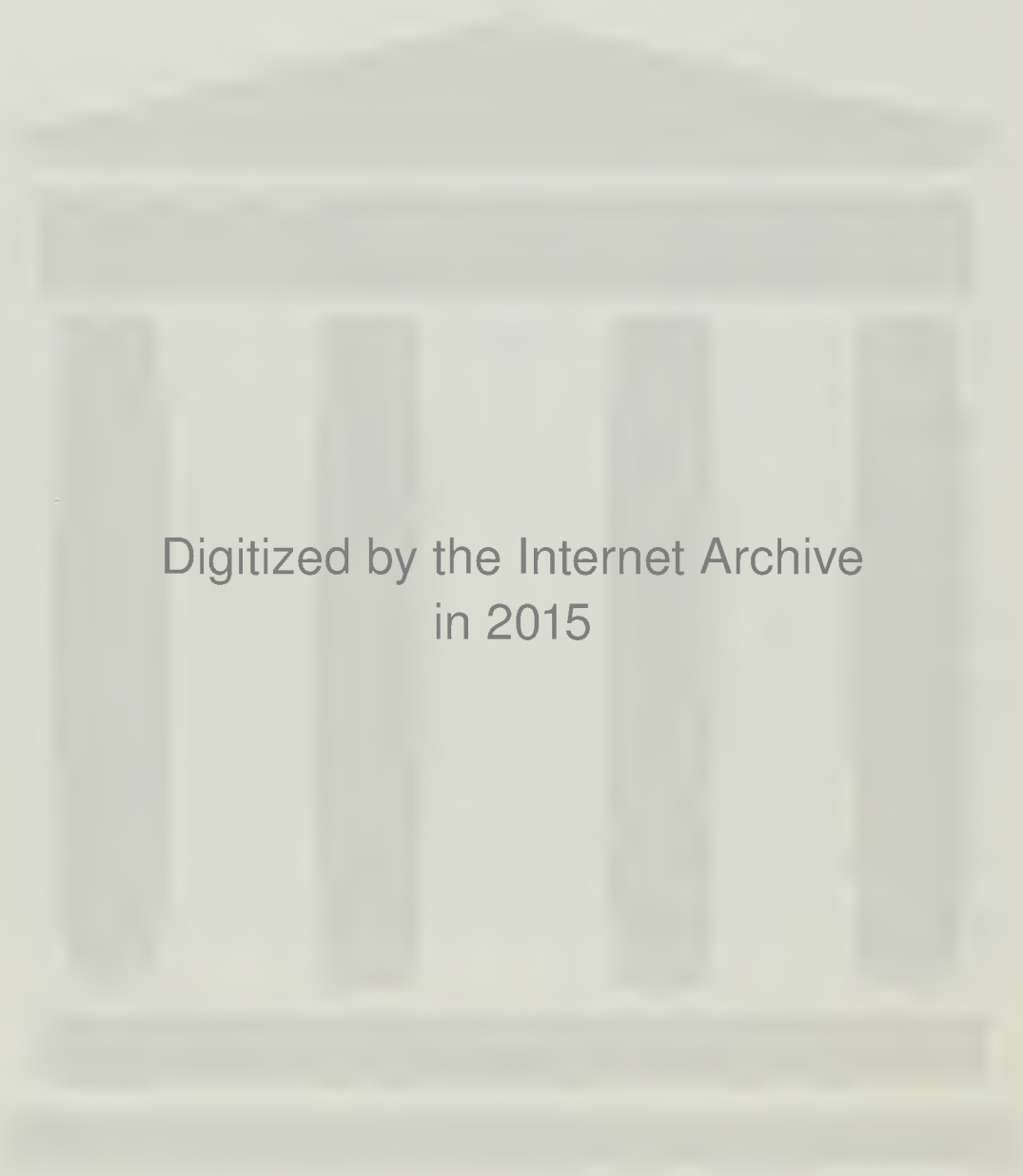

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I. Summary

Chapter II. Introduction

This is the first comprehensive water quality inventory for Montana since 1976. Since the last 305(b) report was prepared four years ago, a number of new tools have been developed for assessment of water quality in Montana. These tools include a stream fishery data base, computerized summaries of Montana water quality data, and a biological monitoring program. Perhaps the most significant contribution to water quality assessment in Montana has been the massive amount of information collected on nonpoint source pollution over the last four years by the State, Areawide, and Indian 208 organizations.

Chapter III. Current Water Quality Conditions and Recent Trends

A. Monitoring Programs

Water quality monitoring programs are described for five federal agencies and the State of Montana. Also described is the state's new Biological Monitoring Program, which will be the focus of water quality trend assessments in future 305(b) reports. Monitoring has expanded significantly over the last several years, primarily because of the emerging importance of nonpoint source pollution and the new laws designed to control it.

B. Assessment of Water Quality

The following waters currently are not supporting fishing and/or swimming along all or a portion of their length:

Statewide 208 Area--

- Beaverhead River
- Milk River
- Muddy Creek (Sun River)
- Prickly Pear Creek
- Silver Bow Creek

Blue Ribbons 208 Area--

- Bozeman Creek
- Camp Creek
- Cement Creek
- Dry Creek
- East Gallatin River
- Elk Creek
- Godfrey Creek
- Moore's Creek
- Yellow Dog Creek

Flathead 208 Area--

Ashley Creek
Crow Creek
Hot Springs Creek
Mission Creek
Post Creek

It is expected that more streams will be added to this list as the Statewide 208 nonpoint source pollution assessment program shifts into a more site-specific, field-oriented phase. Most of the known unswimmable and unfishable waters in Montana are that way because of nonpoint source pollution, which, in some cases, is aggravated by improperly treated municipal or industrial discharges.

C. Evaluation of Water Quality Trends

Seventeen of the 86 STORET-based water quality monitoring stations in Montana active in 1978 had levels of one or more parameters that exceeded water quality standards or criteria. At 25 of these same 86 stations, significant statistical differences were observed for one or more parameters in 1978 compared with aggregated data for 1975, 1976, and 1977. Conditions were improving for nine station/parameter combinations but were degrading for 41 station/parameter combinations. Parameter concentrations were at critical levels in 1978 for 17 of the degrading situations.

D. Lakes

A statewide inventory is now being conducted to assess the trophic status of Montana's public lakes. Two lakes--Sacajawea and Georgetown--have been funded in FY 1980 for upgrading under the EPA Clean Lakes Program.

Chapter IV. Special Water Quality Problems

A. Groundwater

Threats to groundwater quality are increasing in Montana, largely because of increasing numbers of in situ mining operations and surface wastewater impoundments. In 1979 the Department of Health and Environmental Sciences established regulations specifically for aquifer protection during in situ uranium mining. Although a survey of Montana wastewater impoundments revealed little existing impact on groundwater quality, more instances of groundwater pollution might occur in the future as more impoundments are constructed, more water wells are constructed near impoundments, and plumes of contaminated water have had more time to spread. The Water Quality Bureau is currently developing regulations for protection of shallow aquifers from surface seepage, which, along with groundwater quality standards, will be promulgated by December 31, 1981. Other groundwater problems have been identified in subdivision developments at South Libby Flats, Seely Lake, Florence, and Rattlesnake. In addition, a sole source petition under the Safe Drinking Water Act has been submitted to EPA for a portion of the Helena Valley by the Lewis and Clark County Health Department.

B. Saline Seep

Saline seep has impaired productivity on over 200,000 acres of land in Montana. Artificial drainage of seep areas poses the most serious threat

to surface water quality. The Water Quality Bureau now requires discharge permits for such drains and issues permits only when the proposed discharge clearly will not degrade existing water quality. The overall effect of saline seeps on groundwater is not well understood.

C. Dewatering

Dewatering is Montana's priority nonpoint source "pollution" problem. Several of Montana's prized fishing streams are critically affected by agricultural water diversions during the irrigation season. The state's Soil and Water Conservation Districts have identified a total of 873 dewatered stream miles in the Statewide 208 area. The Water Quality Bureau is currently developing a strategy for identifying the most critically dewatered streams from the standpoints of maintaining instream water quality and protecting public water supplies. The Department will then pursue instream flow reservations on the highest priority streams as funds will allow.

D. Drinking Water

Except for turbidity, the quality of surface supplies in western Montana is generally good. Supplies in eastern Montana, particularly groundwater supplies, are generally high in total dissolved solids. Of the 609 community water systems in Montana, 13 have turbidity problems, 13 have fluoride problems, four have nitrate problems, and one each has arsenic and selenium problems.

E. Fish Kills

Eight major fish kills have occurred in Montana since 1976. These have affected an estimated 17.5 river miles and killed an estimated 50,000 fish. Of the six kills that occurred in 1979, agricultural pesticides were listed as a causative agent in five cases.

F. Ammonia

Thirty-five municipalities have been identified as causing potential ammonia toxicity problems in receiving waters. Intensive surveys are now being conducted to determine whether problems actually exist. Ammonia toxicity problems have been documented in the East Gallatin River below the Bozeman STP and discharge limits have been established accordingly.

G. Energy Development

Montana is nationally known for its high quality waters, its prime fishing, and its tremendous energy reserves. The current emphasis on domestic energy supply portends grave consequences for Montana water quality. Anticipated or potential developments in the near future include seven major coal mines, two coal-fired electric generation facilities, six coal gasification or liquifaction plants, and ten major hydropower facilities.

H. Sediment--Muddy Creek

Sediment, along with salinity and dewatering, is one of Montana's "big three" water quality problems. Muddy Creek, a tributary of the Sun River in

northcentral Montana, is one of the state's worst sediment problems and one of few for which remedial land management practices have been prescribed. Within ten years it is predicted that the sediment load in Muddy Creek can be reduced by 75 percent.

Chapter V. Water Quality Goals and Control Programs

A. 1983 Goals and Attainment

The following waters probably will not be fishable and/or swimmable by 1983:

Statewide 208 Area--

Muddy Creek (Sun River)
Prickly Pear Creek below E. Helena
Silver Bow Creek

Blue Ribbons 208 Area--

Bozeman Creek below Kagy Boulevard
Godfrey Creek
Camp Creek
Elk Creek
Dry Creek
Cement Creek

Flathead 208 Area--

Crow Creek
Hot Springs Creek
Mission Creek
Post Creek

In all cases, some form of nonpoint source pollution will be the principal reason for not meeting the 1983 goals. It is expected that additional unfishable and unswimmable streams will be added to this list because of more detailed assessments to be conducted between now and 1983.

B. Controls

Water pollution control programs and staffing expanded dramatically during the 1970's in response to public demand for water quality protection. However, legislative support for water pollution control programs has waned in recent years and funding levels are static or receding. Recommendations are made for targeting priority issues and optimizing expenditures.

Chapter VI. Costs and Benefits

It is not presently possible to accurately identify the costs and benefits of meeting the goals of the Clean Water Act. It is estimated that an annual expenditure of one and one-quarter million dollars will be required by FY 1983

to develop general and site-specific control programs for all types of nonpoint source pollution problems in Montana. Various estimates of actual on-the-ground control costs are presented for different types of nonpoint source pollution problems in different parts of the state. Correction of the remaining point source problems will be accomplished primarily through the planned expenditure of about 82 million federal dollars by the Montana Construction Grants Program through FY 1983.

II. Introduction

This is the 1980 water quality inventory for Montana pursuant to Section 305(b) of the Federal Water Pollution Control Act (P.L. 92-500) as amended by the Clean Water Act of 1977 (P.L. 95-217):

> (1) Each state shall prepare and submit to the Administrator by [January 1, 1975, and shall bring up to date each year thereafter,] *April 1, 1975, and shall bring up to date by April 1, 1976, and biennially thereafter,* a report which shall include--
>
> (A) a description of the water quality of all navigable waters in such State during the preceding year, with appropriate supplemental descriptions as shall be required to take into account seasonal, tidal, and other variations, correlated with the quality of water required by the objective of this Act (as identified by the Administrator pursuant to criteria published under section 304(a) of this Act) and the water quality described in subparagraph (B) of this paragraph;
>
> (B) an analysis of the extent to which all navigable waters of such State provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities in and on the water;
>
> (C) an analysis of the extent to which the elimination of the discharge of pollutants and a level of water quality which provides for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allows recreational activities in and on the water, have been or will be achieved by the requirements of this Act, together with recommendations as to additional action necessary to achieve such objectives and for what waters such additional action is necessary;
>
> (D) an estimate of (i) the environmental impact, (ii) the economic and social costs necessary to achieve the objective of this Act in such State, (iii) the economic and social benefits of such achievement, and (iv) an estimate of the date of such achievement; and
>
> (E) a description of the nature and extent of nonpoint sources of pollutants, and recommendations as to the programs which must be undertaken to control each category of such sources, including an estimate of the costs of implementing such programs.
>
> (2) The Administrator shall transmit such State reports, together with an analysis thereof, to Congress on or before October 1, 1975, and [annually] *October 1, 1976, and biennally* thereafter.

Additional guidance, provided by EPA Region VIII, was compiled from a March 8, 1979 EPA memorandum (WH-551) and the Basic Water Monitoring Program, EPA 440/9-76-025.

There has been a span of four years since the last comprehensive water quality assessment for Montana was published. The last 305(b) water quality inventory was prepared in May 1976. The first was prepared one year earlier (April 1975).

Recognizing this lapse in reporting, the FY 1980 Montana/EPA Agreement identified the following priorities relevant to the state's 305(b) responsibilities:

1) Prepare FY 1980 305(b) report incorporating physical, chemical and biological data.
2) Develop a water quality index to assist in the development of improved 305(b) reports.

Although the first priority will be met upon completion of this report, the second priority was only partially realized. An appropriate diversity index has been adopted to ease the evaluation of biological benthic data for assessment of water quality However, development, or even outright adoption, of a comprehensive and universally applicable water quality index for Montana has proven to be an elusive, if not a totally unreachable, goal. Nevertheless, the Water Quality Bureau was successful in developing a water quality index tailored to streams in the Yellowstone River drainage.

This report represents a significant departure from the two previous 305(b) reports for Montana in that much less emphasis is placed on the number of stream miles affected by the various pollution sources as an indicator of water quality. Our experiences with this approach have proven it to be somewhat misleading, if not dangerous, largely because of definition problems and differing points of view as to what constitutes an "effect." For example, dewatering may be a problem to an agriculturalist only when a stream is totally dry, but to a fishery manager (and to the fish themselves) dewatering may become critical long before the stream dries up. The bottom line in our rejection of this type of indicator is that it is not amenable to objective, systematic measurement from year to year; rather, estimates of stream miles affected by various pollution sources are largely a function of the observer's predisposition toward pollution and his or her concept of "effect." The estimates simply are not sensitive to actual instream changes in water quality.

A number of new tools for assessing water quality condition and trends are introduced in this year's report. For the first time we make use of the Interagency Stream Fishery Data Base developed by the Montana Department of Fish, Wildlife and Parks and others. The form used by fishery biologists to rate Montana fishing streams includes a number of categories assessing water pollution and water quality management needs. Data in these categories that have been entered into the fishery data base were recalled and summarized for purposes of water quality assessment. Also for the first time, the entire computerized water quality data base currently available to the Department of Health and Environmental Sciences was reviewed to determine the number and location of samples in which criteria for selected parameters have been exceeded. A series of maps was prepared to display the distribution of "exceedences" for each parameter.

For evaluation of water quality trends, this report makes first use of computerized analytical summaries of Montana water quality data resident in STORET as provided by EPA Region VIII. Data from 1975-1978 for the active monitoring stations in Montana were used for trend analyses. Also for the

first time in Montana, baseline biological benthic data are presented for 85 stations statewide. These data cover the period 1977-1979 and are expressed in terms of biological diversity using Shannon's Index (d). Each station will be revisited every even-numbered year beginning in 1980, which will allow for biological trend analyses to begin with the 1982 305(b) report.

Perhaps most importantly, a significant body of knowledge on nonpoint source pollution has been accumulated over the intervening years since the last 305(b) report was prepared in 1976. Consequently, a large portion of this report is devoted to a comprehensive, up-to-date assessment of nonpoint source pollution in Montana. This assessment was based on the results of numerous studies conducted by the four (now three) areawide 208 planning agencies, the six Indian 208 planning agencies, and the statewide 208 water quality management planning effort.

This report was assembled by the staff of the Water Quality Bureau, Montana Department of Health and Environmental Sciences, with assistance from the Montana Operations Office of the U. S. Environmental Protection Agency. We are indebted to the U. S. Forest Service (Region 1), the Bureau of Land Management (Montana State Office), the Soil Conservation Service (Montana State Office), and the U. S. Geological Survey (Water Resources Division--Helena) for providing timely information on water quality monitoring and/or management programs. Special thanks are extended to Mr. George Holton, Assistant Administrator of the Fisheries Division, Montana Department of Fish, Wildlife and Parks, for assisting with retrieval and interpretation of information contained in the Interagency Stream Fishery Data Base.

III. CURRENT WATER QUALITY AND RECENT TRENDS

A. Monitoring Programs

1. Federal Programs

Numerous federal agencies are involved in collecting water quality information in Montana. Although some agencies (USGS, EPA) support long-term monitoring stations, the majority of monitoring is conducted for short-term projects. The federal agencies that have contributed data to this report include the Forest Service (FS), Bureau of Land Management (BLM), Soil Conservation Service (SCS), Geological Survey (USGS), and the Environmental Protection Agency (EPA). The descriptions which follow briefly summarize the major monitoring activities of each agency.

a. Forest Service

The Forest Service has undertaken substantial nonpoint water quality monitoring in the 10 national forests in Montana. Total monitoring costs for 1978 and 1979 are slightly over $500,000. Table 1 is a summary of expenditures (by Forest) for nonpoint source water quality monitoring in 1978 and 1979. The Table distributes costs by type of station (fixed or project), and class of data collected (physical, chemical, biological).

Region I is presently in the process of documenting water quality management goals, trends, situation statements, standards, and guidelines for forest planning as a part of the regional planning process under the National Forest Management Act. An additional report is currently being prepared which addresses special water quality projects, summarizes 208 implementation efforts to date, and describes problems with coordinating 208 efforts with other forest landowners. The Forest Service has also provided information on costs devoted to water quality improvement on forest lands during 1978 and 1979. This information can be found in Chapter VI.

b. Bureau of Land Management

The BLM is currently conducting water quality monitoring in three main areas: (1) water quality reconnaissance for multiple use planning, (2) multiple use reservoir studies, and (3) coal hydrology investigations. These programs are discussed in more detail in the following section.

(1) Water Quality Reconnaissance on Public Lands in Montana

This work was begun in 1976 in Beaverhead County to provide a water quality data base for BLM multiple use planning. This is a continuing effort now extending into the Milk River Basin (Valley, Phillips and Blaine Counties). Additional sampling stations will be established in the Big Dry area (Garfield, McCone, Richland, Dawson, Prairie and Rosebud Counties) during the Spring of 1980.

About 121 stream sampling stations have been monitored for a period of one to three years for physical, chemical and bacteriological parameters. The

TABLE 1

National Forests - Montana

Expenditures for Non - Point Water Quality Monitoring
1978 & 1979

National Forest	No. of Stations*	Year	Total	% Baseline	% Project	% Physical	% Chemical	% Bio
BEAVERHEAD	127	1978	$50,000	80	20	60	35	5
		1979	56,000	80	20	60	35	5
BITTERROOT	36	1978	35,000	90	10	10	80	10
		1979	28,000	75	25	20	65	15
CUSTER	**	1978	5,000	100	0	30	45	25
		1979	5,000	100	0	15	75	10
DEERLODGE	142	1978	38,000	32	68	57	43	0
		1979	38,000	32	68	57	43	0
FLATHEAD	38	1978	45,783	100	0	55	45	0
		1979	16,240	100	0	55	45	0
HELENA	12	1978	1,000	0	100	50	50	0
		1979	14,000	20	80	40	30	30
GALLATIN	5	1978	16,000	60	40	30	70	0
		1979	16,700	60	40	24	60	16
KOOTENAI	**	1978	38,300	40	60	50	40	10
		1979	32,000	15	85	65	15	20
LEWIS & CLARK	36	1978	12,000	0	100	50	50	0
		1979	4,000	0	100	100	0	0
LOLO	23	1978	5,000	10	90	90	10	0
		1979	5,000	10	90	90	10	0
TOTAL	419	1978	246,083					
		1979	214,940					

* Operated during all or a portion of the period of record
** Not available

streams are visited for sampling, instantaneous flow measurement and a crest stage reading about 12 to 20 times per year. In addition to the stream stations, numerous small reservoirs, wells and springs have also been sampled. BLM is in the process of entering all BLM acquired water quality data on the EPA STORET computer system. It is estimated that all of the data acquired will be entered on StTORET by the end of FY 80.

Table 2 is a "typical" sampling schedule for stream water quality stations.

(2) Multiple Use Reservoir Water Quality Studies

The purpose of these studies is to undertake a limnological reconnaissance of lakes and reservoirs located on public lands in Montana. This study is to provide water quality data that would help determine the types of uses suitable for these waters. Reservoir uses under consideration by the BLM include: livestock watering; waterfowl production; fish propagation; and body contact recreation. Table 3 lists the names and locations of the reservoirs being studied.

(3) Coal Hydrology Program

Beginning in 1975, BLM, in cooperation with the U. S. Geological Survey - WRD, has been studying the surface and groundwater resources of eastern Montana for the purpose of assessing potential water related implications of coal development. A sizable portion of this effort has been directed toward surface and groundwater quality. All of the data collected is published by the USGS in their annual basic data reports. In addition, numerous summary and interpretive reports have been published since 1975. This program, referred to by the acronym EMRIA, is modified somewhat from one year to the next to reflect the current state of knowledge and changing coal management emphasis. The following work item descriptions reflect those portions of the current fiscal year program having water quality objectives.

(a) Maintain Network of Stream-Discharge and Water Quality Monitoring Sites

Objectives: Collect streamflow and water quality data at key locations to supplement other programs. The data are essential in defining runoff from potential impact areas, determining streamflow characteristics, and providing a data base from which future changes can be analyzed.

(b) Groundwater Monitoring

Location: Powder River and Fort Union coal regions of eastern Montana.

Objectives: To provide groundwater data base from which an assessment can be made of the resource; future responses to stresses can be predicated and pollution and supply problems can be detected and defined. This activity provides for long-term collection of groundwater data from selected observation wells. Specifically, wells monitored in EMRIA study sites are incorporated in this program to extend periods of data collection.

TABLE 2

TYPICAL SAMPLING SCHEDULE FOR BLM STREAM WATER QUALITY STATIONS

TIME PERIOD	ITEM TO BE COLLECTED AT EACH SAMPLING STATION	NUMBER OF TIMES THE ITEM MUST BE COLLECTED DURING THE INDICATED TIME PERIOD ASSUMING RUNOFF OCCURS.
February 15 to April 30	Rainfall measurement	6
	Discharge measurement	6
	Bacteriological sample	1
	Suspended sediment sample	6
	Conductivity, temperature, pH	6
	Chemical quality sample	2
	Crest stage reading	6
	Staff gage reading	6
May 1 to July 15	Rainfall measurement	3
	Discharge measurement	3
	Bacteriological sample	1
	Suspended sediment sample	3
	Conductivity, temperature, pH	3
	Chemical quality sample	2
	Crest stage reading	3
	Staff gage reading	3
July 16 to September 30	Discharge measurement	1
	Bacteriological sample	1
	Suspended sediment sample	1
	Conductivity, temperature, pH	1
	Chemical quality sample	1
	Crest stage reading	1
	Staff gage reading	1
	Rainfall measurement	1
October 1 to December 20	Rainfall measurement	1
	Discharge measurement	1
	Bacteriological Sample	1
	Suspended sediment sample	1
	Conductivity, temperature, pH	1
	Chemical quality sample	1
	Crest stage reading	1
	Staff gage reading	1

TABLE 3

RESERVOIRS TARGETED FOR BLM MULTIPLE USE WATER QUALITY STUDIES

Valley County

Station #	Station Location
1.	VR-9, Air Base Ponds NE¼ 13, T. 31 N., R. 39 E. (2 ponds)
2.	VR-61, Langen Reservoir NW¼ 26, T. 33 N., R. 38 E.
3.	VR-82, SW¼ 28, T. 34 N., R. 39 E.
4.	Unnamed, NE¼ 34, T. 37 N., R. 38 E.
5.	Unnamed, NW¼ 11, T. 36 N., R. 38 E.
6.	Unnamed, SE¼ 27, T. 36 N., R. 36 E.
7.	Unnamed, NW¼ 9, T. 35 N., R. 36 E.
8.	Unnamed, SW¼ 33, T. 35 N., R. 37 E.
9.	Gay, SW¼ 2, T. 33 N., R. 37 E.
10.	VR-64, NW¼ 13, T. 33 N., R. 37 E.
11.	Hose, SE¼ 17, T. 33 N., R. 37 E.
12.	Unnamed, NW¼ 35, T. 34 N., R. 37 E.

Phillips County

GS #	Reservoir Name	Location
14	PR-22	T. 36 N., R. 30 E., Sec. 13
15	Alternate	T. 37 N., R. 32 E., Sec. 29
16	Whitewater Lake (North)	T. 36 N., R. 31 E., Sec. 35
17	Whitewater Lake (South)	T. 35 N., R. 31 E., Sec. 1
18	Cool Pit	T. 35 N., R. 31 E., Sec. 24
19	King	T. 24 N., R. 30 E., Sec. 15
20	PR-18	T. 25 N., R. 30 E., Sec. 5
21	Parrot Flats	T. 26 N., R. 27 E., Sec. 16
22	PR-71	T. 29 N., R. 28 E., Sec. 22
23	Bennett Lake	T. 28 N., R. 30 E., Sec. 1
24	Empire	T. 28 N., R. 29 E., Sec. 22

Various Counties - Miles City District

Reservoir Name	Location	County
Sidney Reservoir	T. 5 S., R. 59 E., Sec. 29	Carter
Jack Rabbit Detention Dam	T. 2 S., R. 58 E., Sec. 13	Carter
Ridge Reservoir	T. 5 S., R. 57 E., Sec. 1	Carter
Side Hill Reservoir	T. 9 S., R. 57 E., Sec. 34	Carter
Clark Reservoir	T. 13 N., R. 48 E., Sec. 18	Prairie
Grant Reservoir	T. 13 N., R. 48 E., Sec. 21	Prairie
Pasture No. 1 Reservoir	T. 11 N., R. 52 E., Sec. 2	Prairie
Coldwell Reservoir No. 2	T. 21 N., R. 40 E., Sec. 10	Garfield
Mid-Flat Creek Reservoir	T. 21 N., R. 40 E., Sec. 4	Garfield
Homestead Reservoir	T. 14 N., R. 49 E., Sec. 7	Prairie
Coal Creek Reservoir	T. 13 N., R. 51 E., Sec. 35	Prairie
Big Drop Reservoir	T. 13 N., R. 56 E., Sec. 9	Dawson
Pass Creek Reservoir	T. 21 N., R. 40 E., Sec. 5	Garfield

(c) Salinity Modeling of Tongue River

Location: Tongue River below Tongue River Dam.

Objective: To construct and calibrate a digital model of the Tongue River which will simulate the salinity of the river through and downstream from existing and proposed mines. The model would be useful in simulating salinity in the river under various conditions of flow and development. This model would provide a tool for evaluating cumulative, off-site effects of various mine operations.

(d) Network Analysis

Location: Fort Union and Powder River coal regions in eastern Montana.

Objectives: Numerous water quality stations have been operated throughout the Fort Union coal region to obtain basic data needed to evaluate the impacts of mining and the potential for reclamation. Analysis of the data is needed to define geo-chemical processes, determine relationships and evaluate the necessity of modifying the network. In addition, modeling techniques should be applied to evaluate regional relationships between water quality and land use, geology and runoff.

c. Soil Conservation Service

The SCS conducts several activities which involve water quality considerations. The major activities are: (1) stream inventories; (2) erosion inventories; (3) watershed projects; (4) technical assistance; and (5) sanitary landfill investigations.

A brief discussion of each of these activities is presented below.

(1) Stream Inventories

Stream inventories are conducted by SCS to provide information on stream problems which can be used to develop a systems management approach to correction of the problems. Inventories typically identify streambed and bank alterations, including rock riprap, car bodies, channel changes, irrigation diversions, eroded banks, and critical sediment sources, and may also include other physical and biological inventories. Recent stream inventories were conducted on selected portions of the following rivers in the year indicated:

Whitefish River - 1976
Ruby River - 1976
Bitterroot River - 1978
Jefferson River - 1975
Rock Creek of the Clark's Fork of the Yellowstone - 1977
Stillwater - 1978
Lower Big Hole - 1975

The following stream inventories are planned for 1980:

Beverhead River
Clark's Fork of the Yellowstone
Lake Creek in the Kootenai Basin
Prickly Pear Creek

(2) Erosion Inventory

The Erosion Inventory is being used to develop a state and national perspective on erosion trends and problems as part of the Resources Conservation Act (RCA). The initial phase of this land inventory and monitoring program (LIM) concentrated on random plot determinations of land erosion, without determining impacts upon receiving streams, whereas phase II of the program will evaluate wind and gully erosion with the intent of relating erosion more directly to water quality.

(3) Watershed Projects

The SCS has several watershed projects under consideration which have special monitoring features. These projects are located in the following watersheds: Lower Birch Creek (Marias River drainage), Grove Creek, (upper Clark Fork River drainage), and the Boulder River (Jefferson River drainage). These projects generally are designed for multiple purposes.

(4) Technical Assistance

The SCS provides technical assistance to cost-shared projects funded under the Agricultural Conservation Program (ACP). These projects are being directed more and more toward water quality improvement, with a resulting need for monitoring project impacts. An example of such impact monitoring by SCS is that associated with the installation of dairy waste holding pits in the Gallatin River drainage. Similar investigations should be possible through joint SCS and Water Quality Bureau or Areawide 208 efforts as additional water quality oriented ACP practices are installed in critical problem areas.

(5) Sanitary Landfill Investigations

Approximately 25 sanitary landfill site evaluations have been conducted by the SCS during the past two years. The purpose of these evaluations was to provide landfill owners with data on soils, hydrology, geology, and operation. These data are needed in applications to the Montana Solid Waste Bureau for licensing purposes.

d. U. S. Geological Survey

The USGS conducts all types of surface and groundwater monitoring for multiple purposes. Although a large part of this monitoring effort is conducted at the request of, and with the support of other agencies, the USGS does maintain a comprehensive monitoring network in Montana for its own purposes. (See

Appendix A). Many of these stations provide long term water quality trend indicators which are described in further detail in Section III. C. of this report.

e. Environmental Protection Agency

EPA provides financial assistance to the Montana Water Quality Bureau and USGS monitoring networks, as well as other 208 water quality monitoring projects. This support allows these agencies to increase the parameter coverage for selected stations, particularly those which are a part of the National Water Quality Surveillance System (NWQSS) and the energy impact area system (see Tables 4 through 7 and Figure 1).

2. State Programs

Water quality monitoring for the state of Montana is the responsibility of the Water Quality Bureau, Montana Department of Health and Environmental Sciences. The objective of the Bureau's monitoring program is to provide information for water quality management. Hence, the monitoring program is highly activity related, addressing mining, forestry, agriculture, urbanization, and industrialization.

The Bureau's monitoring program generally follows the guidelines set forth in the "Basic Water Monitoring Program" document prepared by the Environmental Protection Agency (EPA 440/9-76-025). The Bureau's monitoring program includes: (a) fixed station monitoring; (b) intensive surveys; (c) quality assurance; and (d) data processing and handling.

a. Fixed Station Monitoring--chemical/physical

Montana has two networks for chemical/physical fixed station monitoring: an effluent network (see "Assessment of Water Quality--Point Source Inventory") and an ambient network. The effluent network is established to monitor the discharges of MPDES permit holders. Most of the ambient monitoring in Montana is done by the U. S. Geological Survey, Water Resources Division, at stations of their National Stream Quality Accounting Network (NASQAN).

The following is a list of stations included in the State's Ambient Monitoring Network for federal fiscal year 1980: (locations are shown in Figure 2):

1.	St. Mary River at International Boundary	USGS NASQAN
2.	Missouri River at Toston	USGS NASQAN
3.	Marias River near Chester	USGS NASQAN
4.	Missouri River at Virgelle	USGS NASQAN
5.	Musselshell River at Mosby	USGS NASQAN
6.	Missouri River below Fort Peck Dam	USGS NASQAN

TABLE 4

Energy and NWQSS Funded Water Quality Monitoring Stations
in Montana

Energy

Station Number	Station Name
	Yellowstone River Basin
06217500	Yellowstone River at Huntley
06295000	Yellowstone River at Forsyth
06296120	Yellowstone River near Miles City
06307616	Tongue River at Berney Day Schools Bridge
06326530	Yellowstone River near Terry
06324500	Powder River at Moorhead
	Poplar River Basin
06180400	West Fork Poplar River near Bredette
06178000	Poplar River at International Boundary
06179000	East Poplar River at Scoby
06179200	Poplar River above the West fork near Bredette
06181000	Poplar River at Poplar

NWQSS

Station Number	Station Name
06217500	Yellowstone River downstream Billings

STATE: MONTANA AREA: COAL

FY 80 MONITORING PROGRAM (FY 79 FUNDS)

Frequency of Observations
M = Monthly; Q = Quarterly
S = Seasonal (high & low Flow)

USGS Sta. No.	Site Description	Field (1)	Chemical (2)	Nutrients (3)	Carbon (4)	Metals (5)	Periphyton (6)	Rad-Chem (7)	Suspended Sediment	Fedal Coliform	COSTS ANNUAL
06217500	Yellowstone River at Huntley	(8)	(8)	(8)	Q	S	-	-	M	(8)	2,290
06295000	Yellowstone River at Forsyth	M	M	M	Q	S	-	-	M	-	5,640
06296120	Yellowstone River near Miles City	(8)	(8)	(8)	Q	S	-	-	M	-	2,530
06307616	Tongue R. at Berney Day School Bridge	M	M	M	Q	S	-	-	M	-	5,640
06326530	Yellowstone River near Terry	M	M	M	Q	S	-	-	M	-	5,640
06324500	Powder River at Moorhead	M	M	M	Q	S	-	-	M	-	—
								TOTAL			21,740

(1) Field - Water temperature, specific conductance, pH, streamflow and dissolved oxygen.
(2) Chemical - Calcium, magnesium, sodium, potassium, silica, fluoride, iron, bicarbonate, carbonate, chloride, sulfate, dissolved solids (calculated), boron and alkalinity.
(3) Nutrients - Total nitrate-nitrate, total phosphorous, total Kjeldahl nitrogen, and total ammonia.
(4) Carbon - Suspended organic carbon and dissolved organic carbon.
(5) Metals - Total and dissolved metals (As, Al, Be, Cd, Cr, Cu, Pb, Mn, Hg, Ni, Se, V, Zn, Li and Mo).
(6) Periphyton - USGS Schedule #310
(7) Rad-Chemi - Gross alpha and beta, dissolved and suspended radium 226 and uranium.
(8) Furnished by other programs.

TABLE 5

PARAMETER COVERAGE AND SAMPLING FREQUENCY AT EPA FUNDED ENERGY STATIONS--YELLOWSTONE RIVER BASIN

Services to be Provided
Surface Water Quality Monitoring Program in
Canadian Coal Development Impact Areas of the
Poplar River - Montana

FY 1980

Frequency
*M = Monthly Q = Quarterly

Station	Location	Field (1)	Chemical (2)	Nutrients (3)	Metals (4)							Cost
06180400	West Fork Poplar R. near Bredette	M	M	M	Q							5,170
06179000	East Fork Poplar R. near Scobey	M	M	M	Q							4,860
06178000	Poplar R. at Int. Boundary	M	M	M	Q							4,860
06179200	Poplar R. above West Fork near Bredette	M	M	M	Q							5,170
06181000	Poplar R. at Poplar	M	M	M	Q							4,860
										TOTAL		24,920

(1) Field - Streamflow, pii, temperature, turbidity, dissolved oxygen, specified conductance & TSS
(2) Chemical - Calcium, magnesium, sodium, potassium, bacarbonate, carbonate, sulfate, chloride, fluoride, boron, silica, iron, and dissolved solids. (calculated).
(3) Nutrients - Total nitrite and nitrate, total phosphorus, total kjeldahl nitrogen, total ammonia and dissolved ortho-phosphate.
(4) Metals - Dissolved (aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, manganese, nickel, zinc, selenium, and vanadium). Total metals analysts for above will be performed twice-per-year at approximately high and low floor conditions.

*Only 11 samples are collected during year.

TABLE 6

PARAMETER COVERAGE AND SAMPLING FREQUENCY AT EPA FUNDED ENERGY STATIONS--POPLAR RIVER BASIN

Environmental Protection Agency Region VIII
National Water Quality Surveillance System
Cooperative Program USGS

FY-80 Monitoring Program

Frequency of Observation

M = Monthly

USGS Sta.No.	Site Description	Field (1)	Chemical (2)	Nutrients (3)	COD	Coliform (4)	Metals (5)	Suspended Solids (6)				
06217500	Yellowstone River at Huntley	M	M (7)	M	M	M	M	M				$3,580
												$3,580

1. Field - Water temperature, specific conductance, pH, stream flow and dissolved oxygen.
2. Calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate and chloride.
3. Nutrients - Total nitrate-nitrite, total phosphorous, total Kjeldahl nitrogen and total ammonia.
4. Coliform - Fecal.
5. Metals - Total nickel, zinc, silver and cyanide.
6. Suspended solids - parameter code (00530)
7. Furnished by other programs.

TABLE 7

'PARAMETER COVERAGE AND SAMPLING FREQUENCY AT THE EPA FUNDED NWQSS STATION IN MONTANA

FIGURE 1--NWQSS AND ENERGY WATER QUALITY MONITORING STATIONS IN MONTANA FUNDED BY EPA

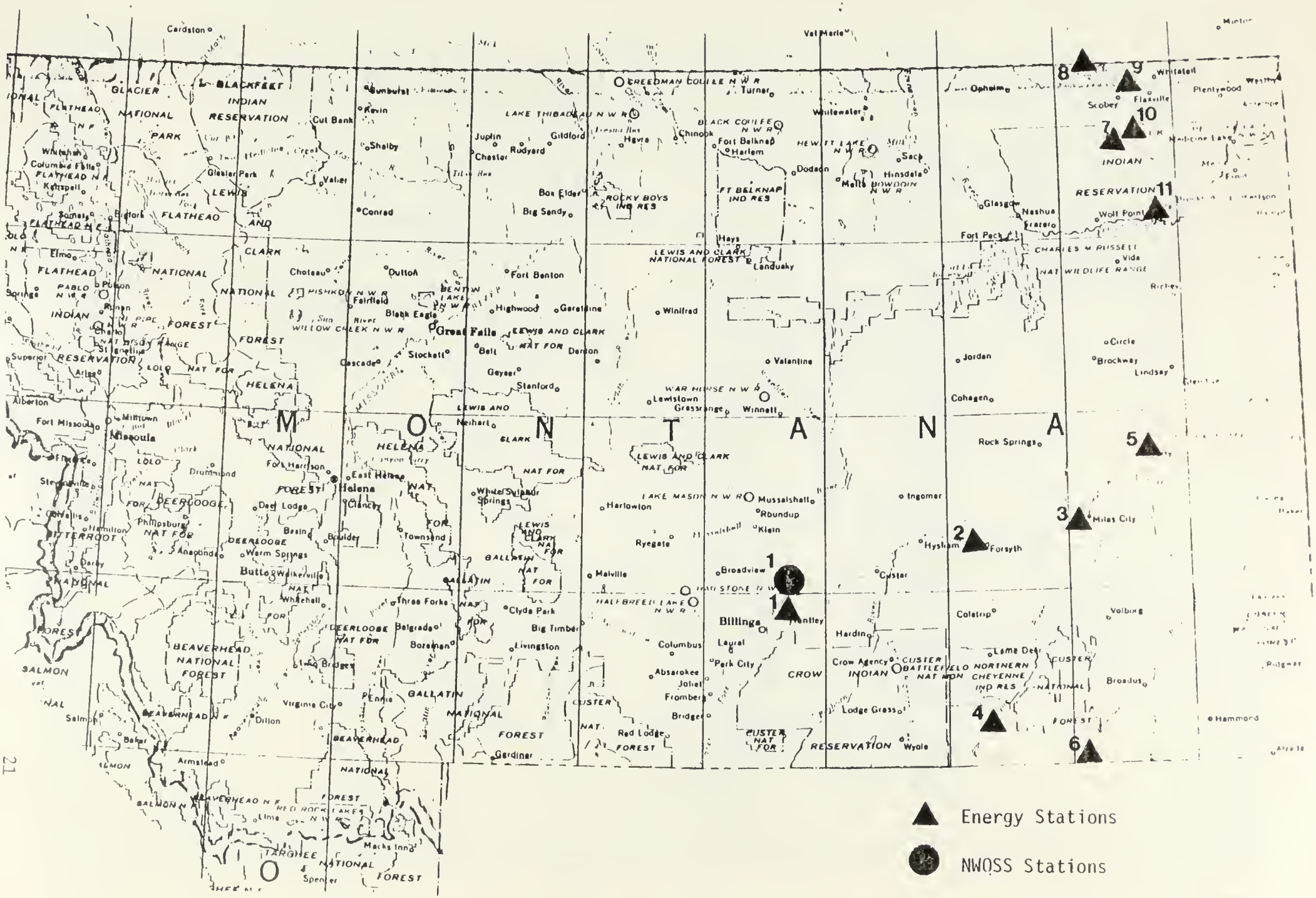
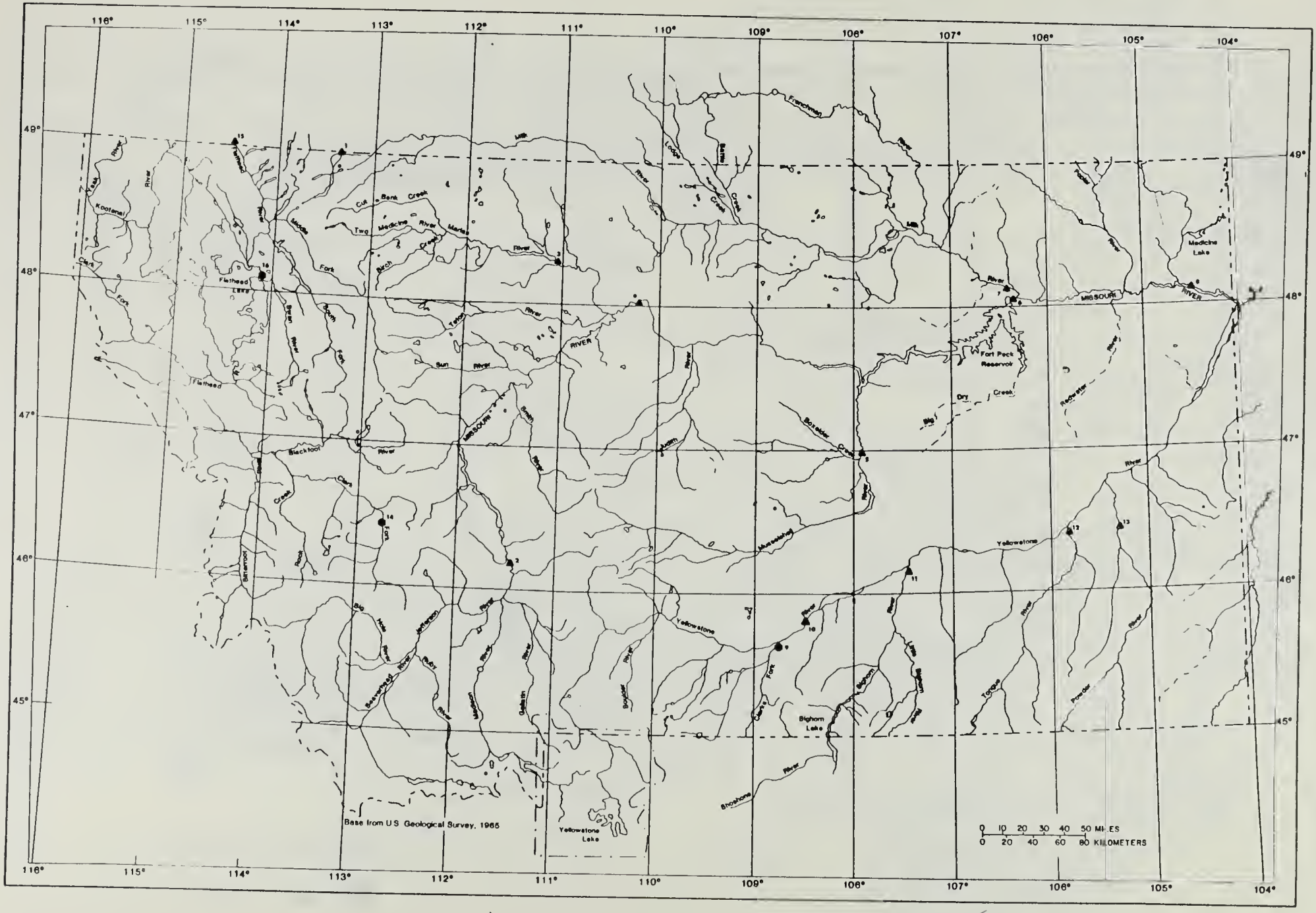


FIGURE 2 - STATE OF MONTANA FIXED-STATION AMBIENT MONITORING NETWORK FOR FY 1980



7.	Milk River at Nashua	USGS NASQAN
8.	Missouri River near Culbertson	USGS NASQAN
9.	Clarks Fork of the Yellowstone at mouth	WQB
10.	Yellowstone River at Billings	USGS NASQAN
11.	Bighorn River at Bighorn	USGS NASQAN
12.	Tongue River at Miles City	USGS NASQAN
13.	Powder River near Locate	USGS NASQAN
14.	Clark Fork River at Deer Lodge	WQB
15.	Flathead River at Flathead, B.C.	USGS NASQAN
16.	Flathead River at Holt	WQB

These stations generally comply with EPA monitoring program requirements in terms of frequency of sampling and parametric coverage, except that TSS, COD, and fish tissue analysis for selected toxics are not included. Beginning in federal fiscal year 1981, the State proposes to designate 7 USGS NASQAN sites as its Ambient Monitoring Network and to supplement coverage at these seven sites with TSS, COD, and fish tissue analyses.

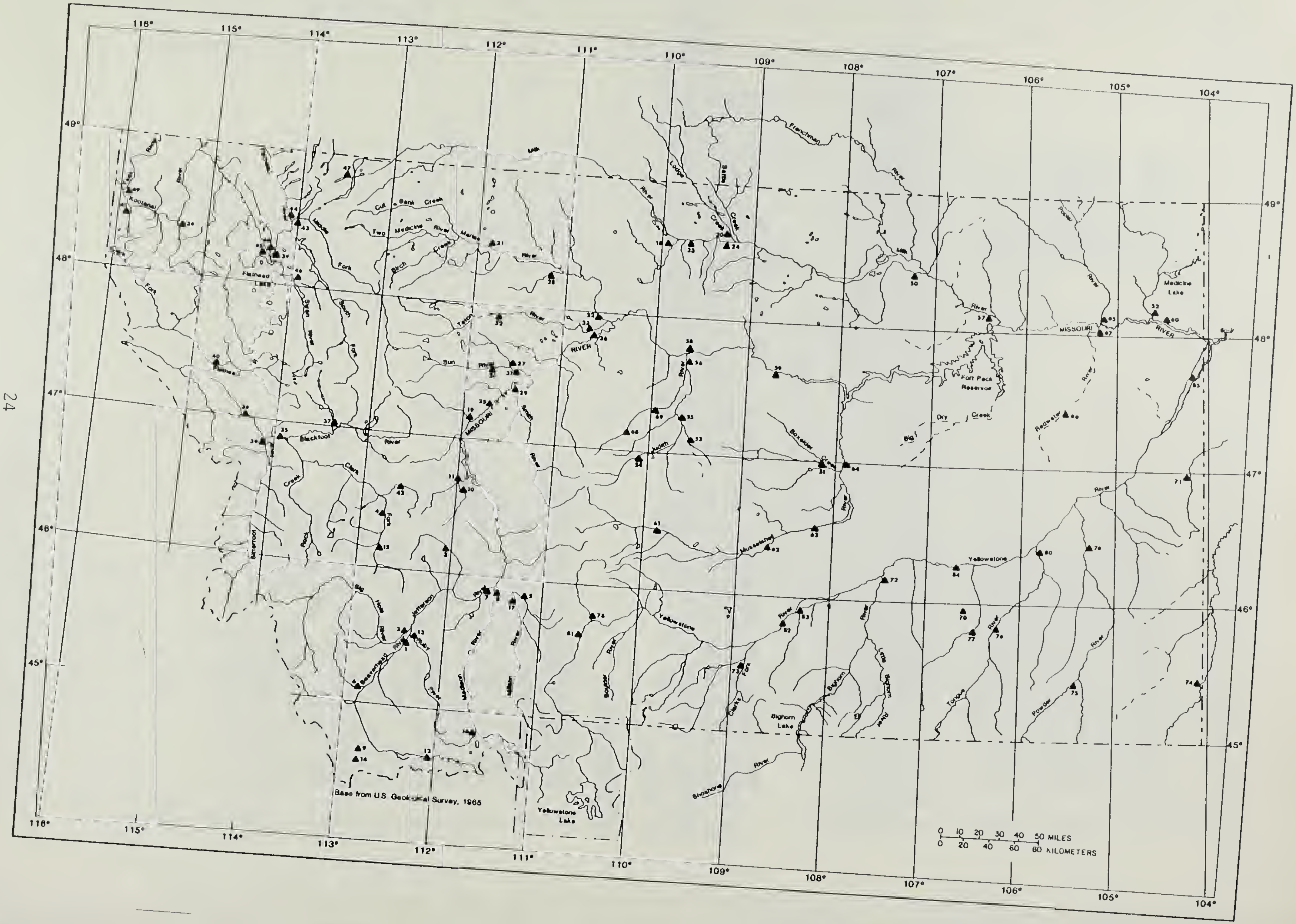
Fixed Station Monitoring--biological

Montana has established a statewide network of biological monitoring stations. The network includes 85 stations on 59 streams statewide, with at least one station in each of the state's major drainage basins (see Figure 3). Seasonal baseline biological conditions were established at each of these stations from 1977 through 1979. The stations are grouped geographically into loops as follows:

SOUTHWEST LOOP

1. Beaverhead River at Twin Bridges
2. Big Hole River near Twin Bridges
3. Boulder River below Boulder
4. Clark Fork River at Deer Lodge
5. East Gallatin River near Belgrade
6. Grasshopper Creek near mouth near Dillon
7. Jefferson River near Three Forks
8. Madison River near Three Forks
9. Muddy Creek at mouth near Dell
10. Prickly Pear Creek at East Helena
11. Prickly Pear Creek near mouth
12. Red Rock River above Lima Reservoir
13. Ruby River near Twin Bridges
14. Sheep Creek above Muddy Creek
15. Silver Bow Creek below Warm Springs Ponds
16. West Fork Madison River near mouth
17. West Gallatin River at Central Park (I90)

FIGURE 3 - STATE OF MONTANA BIOLOGICAL MONITORING NETWORK



NORTHCENTRAL LOOP

18. Big Sandy Creek near mouth
19. Dearborn River near mouth
20. Lodge Creek near Chinook
21. Marias River near Shelby
22. Marias River at Loma
23. Milk River at Havre
24. Milk River above Chinook
25. Missouri River at Cascade
26. Missouri River at Fort Benton
27. Muddy Creek near mouth at Vaughn
28. Pondera Creek near mouth near Chester
29. Smith River near Ulm
30. Sun River near Fort Shaw
31. Sun River below Vaughn
32. Teton River near Dutton
33. Teton River near Fort Benton

NORTHWEST LOOP

34. Bitterroot River near mouth
35. Clark Fork River below Bonner Dam
36. Clark Fork River at Huson RR Bridge
37. Clearwater River near mouth
38. Fisher River at mouth
39. Flathead River near Kalispell
40. Flathead River near mouth
41. Lake Creek near mouth near Troy
42. Little Blackfoot River at Avon
43. Middle Fork Flathead River near mouth
44. North Fork Flathead River near mouth
45. Stillwater River near mouth at Kalispell
46. Swan River near mouth
47. Swiftcurrent Creek near Babb
48. Whitefish River near mouth near Kalispell
49. Yaak River near mouth

NORTHEAST LOOP

50. Beaver Creek near Hinsdale at Beaverton
51. Box Elder Creek near Winnett
52. Big Muddy Creek near mouth near Culbertson
53. Big Spring Creek below Lewistown
54. Judith River near Utica
55. Judith River near Danvers
56. Judith River near mouth
57. Milk River at Nashua

NORTHEAST LOOP (Continued)

58. Missouri River below Judith River
59. Missouri River at Fred Robinson Bridge
60. Missouri River at Culbertson
61. Musselshell River at Harlowton
62. Musselshell River above Roundup at Bundy
63. Musselshell River below Roundup at Delphia
64. Musselshell River at Mosby
65. Poplar River at mouth at Poplar
66. Redwater River at Circle
67. Redwater River near mouth
68. Wolf Creek at Stanford
69. Wolf Creek at Denton

SOUTHEAST LOOP

70. Armell's Creek (East Fork) near Colstrip
71. Beaver Creek at Wibaux
72. Bighorn River at Bighorn
73. Clark's Fork River near Laurel at Edgar
74. Little Missouri River at Capitol
75. Powder River at Broadus
76. Powder River near Miles City at Locate
77. Rosebud Creek near Colstrip
78. Shields River near mouth
79. Tongue River at Brandenberg
80. Tongue River at Miles City
81. Yellowstone River near Livingston
82. Yellowstone River at Billings (USGS Station)
83. Yellowstone River near Huntley
84. Yellowstone River at Forsyth
85. Yellowstone River near Sidney

Beginning in the summer of 1980, and every other year thereafter, the Water Quality Bureau will sample the benthic algae and macroinvertebrate communities at each of these 85 sites. Samples will be processed to determine macroinvertebrate and diatom diversity as measures of water quality. These diversity index values will form the basis for biological trend analyses in subsequent 305(b) reports, i.e., in 1982, 1984, 1986, etc.

b. Intensive Surveys

Intensive surveys to determine the adequacy of present wastewater treatment facilities are conducted for communities that pose a potential for exceeding water quality criteria. (See "Special Water Quality Problems--Ammonia".)

Many of the Bureau's intensive surveys address needed technical studies identified by other programs, i.e., biological monitoring. Recent studies of this nature include the Flint Creek Range, the Musselshell River, Prickly Pear Creek, and Muddy Creek.

c. Quality Assurance

The Bureau has implemented the "Minimum Quality Assurance Program" as outlined by the Environmental Protection Agency.

d. Data Processing and Handling

The automated data processing and handling system for Montana's water quality data was realized in FY 1978. Periodic updates are made to the system. When these updates are made, the data are placed on the STORET file.

B. Assessment of Water Quality

1. Basin Descriptions and Water Quality Summaries

Much of the water quality information presented in subsequent chapters of this report is aggregated by drainage basin. This chapter will serve to introduce the reader to these drainage basins by way of descriptions of their physical characteristics and general summaries of water quality conditions in each of their significant hydrologic units.

Systems for delineating drainage basins in Montana are as numerous as the various governmental agencies concerned with the management of water resources in the state. For example, the Water Quality Bureau (Montana Department of Health and Environmental Sciences), the United States Geological Survey, and the Montana Department of Fish, Wildlife and Parks each have adopted a hydrologic cataloging system to best fit its particular needs.

The system adopted and retained by the Water Quality Bureau for water quality management planning is essentially the same as that presented by the old Montana Water Resources Board (An Atlas of Water Resources in Montana by Hydrologic Basin). This system was used by the Bureau to prepare the Water Quality Inventory and Management Plans under Section 303(e) of PL 92-500. Under this system, the state's sixteen "sub-major" drainage basins are further divided into eighty-five minor drainage basins representing the significant tributaries in the state. These minor basins are designated by an alpha-numeric code, e.g., 41T. Hard copies of all water quality data generated by the Department of Health and Environmental Sciences are filed according to these minor basin codes. The basis for the drainage subdivisions, and the codes used to represent these subdivisions, is the Office of Water Data Coordination, U.S.D.I., Geological Survey Atlas of Stream Gaging Stations.

In the meantime, the U.S. Geological Survey published a new system utilizing 100 hydrologic "cataloging units" for Montana, each designated by an eight-digit number representing a "major stream segment." The Environmental Protection Agency requested that the Water Quality Bureau use this latter system in reporting water quality conditions and trends. However, due to the inconvenience in converting from the old U.S.G.S. system adopted by the Water Quality Bureau to the new U.S.G.S. system, this was not always practical. In cases where the old system was retained, e.g., for much of the 208 assessment work, a table is provided (Appendix B) for comparison and, if desired, conversion of one system to the other.

The following descriptions of basin physical characteristics and summaries of basin water quality conditions (by hydrologic cataloging unit) were adapted largely from the water quality inventories and management plans prepared by the Water Quality Bureau pursuant to Section 303(e) of PL 92-500. Both existing and proposed water quality classifications are given for each major stream segment; proposed classifications are listed in parentheses.

a. St. Mary River Basin

The St. Mary River Basin comprises less than one percent of the total land area of Montana. Seventy percent of the basin is in Glacier National Park and 30 percent is on the Blackfeet Indian Reservation. All waters in the basin are headwaters of the Saskatchewan River system of Canada, which drains north and east to Hudson's Bay. Physical characteristics in the basin include the spectacular mountains, glaciers and glacial lakes of Glacier Park, gentler forested terrain at lower elevations, and the rolling rangeland of the St. Mary River valley.

Elevations in the drainage range from over 10,000 feet in Glacier National Park to less than 4,500 feet at the international border. Climate is highly dependent on elevation. Rainfall varies from 120 inches per year in the mountains to 20 inches per year on the prairie. Temperature extremes are generally more pronounced at lower elevations, particularly under the influence of chinook winds in the winter.

The geological and hydrological aspects of the drainage are diverse. Many of the present surface features were formed by mountain glaciers which deposited cobbles and gravels over large areas at lower elevations. Soils are of variable thickness and nature, but generally they are shallow, stony, and punctuated with rock outcrops.

The quality of waters in the St. Mary drainage basin is generally excellent. Population in the basin is sparse and wastewater discharges are few and minor. The primary land use outside Glacier Park is grazing and only a small fraction of the drainage is farmed. The two principal stream segments in the basin are the Belly and the St. Mary rivers.

Belly River (10010001).

The Belly River at the canadian border flows an average of about 300 cfs and its drainage in Montana is confined entirely to Glacier National Park. The basin is relatively inaccessible and undeveloped. All waters in the drainage are nearly pristine and classified A-Open-D_1 (A-1), indicating they are suitable for most beneficial uses with little or no treatment.

St. Mary River (10010002).

The St Mary River flows an average of about 700 cfs at the canadian border. All waters within Glacier National Park are classified A-Open-D_1 (A-1) except a portion of Swiftcurrent Creek. Swiftcurrent Creek from Many Glacier Chalet to Lake Serbourne and all waters outside of the park are classified B-D_1 (B-1). Swiftcurrent Creek is seasonally dewatered and has been subject to hydrologic damage. Otherwise, water quality in the drainage is excellent.

b. Upper Missouri River Tributaries Basin

The Upper Missouri Tributaries Basin, which includes southwestern Montana and northwestern Yellowstone Park, is characterized by several large and distinct mountain ranges separated by broad, flat agricultural valleys with extensive irrigation development. The basin is drained by

the Gallatin, Madison, and Jefferson rivers, which join to form the Missouri River near the town of Three Forks. These and other streams within the drainage are some of the most popular and productive cold water fisheries in America.

Population in the basin has been sparse and strongly tied to agriculture. However, agricultural dominance is declining. Aesthetic qualities of the basin have resulted in a significantly increased tourist and recreation-based industry and in the attraction of many new residents within the last dozen years.

Elevations in the drainage range from over 11,000 feet in several of the mountain ranges to less than 4,500 feet at Three Forks. Precipitation in the valleys is about 12 to 20 inches per year. Peak precipitation occurs in May and June followed by a second lesser peak in September. Summers are generally warm and sunny; Arctic cold air masses sometimes settle in for several days at a time during the winter, dropping temperatures well below zero.

Bedrock formations in the basin include rock types of Pre-Cambrian age. A variety of rocks of Paleozoic age, including shale, sandstone, quartzite, limestone, siltstone, and dolomite, are exposed over broad areas in the mountains. Sediments of Tertiary age are present in the valleys and include thick layers of sandstone, volcanic ash, and unconsolidated mixtures of sand, gravel, silt, and clay. Soils in the basin are highly variable in texture and depth, but the better agricultural soils have been formed on deep, calcareous silty material, probably deposited by wind. There is a moderate water erosion hazard on these soils.

Surface and ground water is generally excellent in quality in the headwaters of the Missiouri River. However, the basin also includes a nearly complete cross-section of Montana water quality problems, including sediment, temperature, dewatering, nutrients, coliforms, eutrophication, and acid mine drainage. Quality typically degrades in a downstream direction with streams picking up more salts, carrying higher nutrient loads, and having higher temperatures. Loads of suspended solids are variable, depending on seasonal flows, local rainfall, runoff, geology and soils, and the position of reservoirs. The numerous reservoirs in the basin tend to average flows and salt concentrations while causing deposition of sediment in slackwater areas and increased streambed erosion below dams.

Eight hydrologic units comprise the Upper Missouri River Tributaries water quality management planning basin: Red Rock, Beaverhead, Ruby, Big Hole, Jefferson, Boulder, Madison and Gallatin.

Red Rock River (10020001).

The Red Rock River is a very hard, calcium-bicarbonate type water with moderate sulfate, sodium, magnesium, and chloride concentrations. Lead, zinc, cadmium, and copper are present in low concentrations of geologic origin. However, recorded low-flow turbidities are significantly higher than in other

major streams in the planning areas, except the Ruby River. Easily eroded soils compounded by overgrazing in the drainage are the likely causes of such turbidities. Overgrazing conditions are similar to those on the West Fork Madison River watershed. Temperatures are not considered adverse for propagation and growth of salmonids and associated aquatic life. All waters in the drainage are classified B-D_1 (B-1).

Beaverhead River (10020002).

Water discharged from Clark Canyon Reservoir is very hard, calcium-bicarbonate type with moderate sulfate levels. Trubidities are low because much sediment is deposited in the reservoir. "Hungry" water discharged from the reservoir may accelerate channel erosion. Calcium, magnesium, sodium, and bicarbonate concentrations are increased by approximately 25 percent between the dam and Twin Bridges, probably due to the input of irrigation return flows and ground water from alluvial deposits along the river.

A number of water quality problems have been identified by studies in the Beaverhead drainage:

1. Water temperatures considered high for a salmonid fishery have been recorded at the USGS station near Twin Bridges.

2. Dewatering occurs frequently in various segments of the Beaverhead River between Barretts Diversion and Twin Bridges.

3. Sediment loads carried by the Beaverhead River at the USGS station near Twin Bridges appear significantly higher than at the dam outlet. Loads are presumed to be a combination of stream bank erosion on the mainstem and erosion in tributary drainages. Releases from Clark Canyon Dam may be the major reason for bank caving on the Beaverhead River. Among the tributaries, erosion in the Grasshopper Creek drainage has been a significant sediment source.

4. Periodically high hydrogen sulfide levels in the Beaverhead River section downstream of Clark Canyon Dam have resulted in at least one fish kill and may be chronically affecting fish populations. Decaying aquatic vegetation in the reservoir is the presumed hydrogen sulfide source.

5. Grasshopper Creek, which enters the Beaverhead about eight miles downstream of Clark Canyon Dam, contributes a significant load of sediment and some metals to the river. All waters in the Beaverhead River drainage are classified B-D_1 (B-1) or better.

Ruby River (10020003).

The Ruby River is a very hard, calcium-bicarbonate type water with maderate sulfate, sodium, and magnesium levels and low chloride concentrations. Lead, zinc, cadmium, and copper levels generally are low and related to watershed geology. Turbidities recorded during low flow periods are higher than all

other major streams in the Upper Missouri Basin except the Red Rock River. Easily eroded soils in the watershed, compounded by poor land management practices, particularly overgrazing, are the likely causes of the high turbidities. All waters in the Ruby River drainage are classified B-D_1 (B-1) or better.

Big Hole River (10020004).

The Big Hole River generally is an excellent quality, moderately hard, calcium-bicarbonate type water with low turbidity and low sulfate, sodium, chloride, and toxic metals concentrations. However, stream temperatures considered adverse for growth and propagation of salmonids and associated aquatic life have been recorded. Temperature fluctuations appear to be affected by diversion for irrigation. The number of irrigation diversions along the river increased significantly during the 1970's. The Big Hole River near Twin Bridges was dry for a period of time during the summer of 1966 and has been critically low in years since. Channelization and construction of diversion works for irrigation have increased stream sediment loads and turbidities. All waters in the Big Hole River drainage are classified B-D_1 (B-1) or better.

Jefferson River (10020005).

The Jefferson River is a very hard, calcium-bicarbonate type water with moderate sulfate, sodium, magnesium, and chloride concentrations. Moderate sediment and turbidities are due to irrigation return flows, natural erosion, and channel erosion. Stream temperatures considered adverse for salmonids and associated aquatic life have been recorded. Toxic metals concentrations are low. All waters in the Jefferson River drainage are classified B-D_1 (B-1).

Boulder River (10020006).

The Boulder River is a low dissolved solids, moderately-hard, calcium-bicarbonate type water with moderate sulfate concentrations. High toxic metals concentrations from acid mine seeps in the Boulder Batholith mining region are causing severe pollution of the Boulder River and some of its tributaries.

Toxic metals discharged from mine seeps upstream of Boulder, Montana, are present in the Boulder River in concentrations reported to cause avoidance reactions to migrating fish. Fish food production, fish growth, and spawning success are inhibited severely in some tributaries. Water quality impairment is due principally to input of sediment and toxic metals from the High Ore and Cataract Creek drainages. Mining activity in other portions of the drainage has resulted in several less significant problems. With few exceptions, waters in the Boulder River drainage meet their designated B-D_1 (B-1) classification.

Madison River (10020007).

The Madison River is a calcium-bicarbonate, moderately-hard water of excellent quality. The Madison River is of drinking water quality, except that treatment would be necessary to control turbidity, arsenic, and fluoride, which at times exceed the U.S. Public Health Service limits.

Sediment from the West Fork of the Madison River is a major water quality problem in the drainage. Temperatures considered adverse for salmonids and associated aquatic life have been recorded upstream of Hebgen Lake (near West Yellowstone, Montana) and downstream of Ennis Lake (near Ennis, Montana). Water temperatures up to 81°F upstream of Hebgen Lake were attributed to thermal activity in Yellowstone Park. Summer temperatures above 70°F are common in the Madison River downstream of Ennis Lake. Ennis Lake, a broad, shallow impoundment near Ennis, Montana, has been shown to increase the temperature of Madison River. Flow releases from Hebgen Dam influence stream temperatures in the Madison River. Hebgen Reservoir produced a bloom of toxic algae in the summer of 1977. In spite of these problems, all waters in the Madison River drainage are classified $B\text{-}D_1$ (B-1).

Gallatin River (10020008).

The West Gallatin River is a high quality, low dissolved solids, and low nutrient mountain stream for most of its length. Water quality of the East Gallatin River is poorer than that of the West Gallatin River. Erosive stream banks, extensive agricultural activity, and the discharge from Bozeman's sewage treatment plant are major factors contributing to increased suspended solids, high nutrients, and high coliform counts. Other smaller streams traversing the Gallatin Valley are affected by agricultural and urban pollutants. All waters in the Gallatin drainage are classified $B\text{-}D_1$ (B-1) or better, except a section of the East Gallatin River, which is classified $B\text{-}D_2$ (B-2).

c. Missouri-Sun-Smith River Basin

This basin includes all lands drained by a 250-mile stretch of the Missouri River in westcentral Montana from the three forks of the Missouri River near Trident to the mouth of the Marias River at Loma. Total drainage area is approximately 11,000 square miles or 7 million acres. Topography in the basin varies from mountainous to rolling plains; the lowest point in the basin is less than 3,000 feet at Loma. Major population centers in the basin are Helena and Great Falls.

Topography is a large factor in the basin's climate. The semi-arid climate of the valleys and rolling plains is typified by cold, dry winters; moist springs; and warm, dry summers. Annual precipitation in these areas usually ranges between 10 and 15 inches. Mountain areas, particularly along the Continental Divide, receive significant snowfall during winter months. Snow depths exceeding 250 inches have been recorded. Melting of this accumulated winter snow greatly amplifies stream flows from April through June. Soils in the Missouri-Sun-Smith basin are as varied as the physiographic features.

Agriculture is the leading industry in the planning areas and livestock production is the major agricultural operation. There are over 3 million acres of pasture and range in the basin. Irrigated lands account for

280,000 acres and dry croplands cover an additional 900,000 acres. Two-thirds of the area is in private ownership or other non-federal control and is used primarily for range or crops. Management of the federal third is largely for grazing and forest use by the U. S. Forest Service and the Bureau of Land Management.

Irrigation is the predominant consumptive use of water in the Missouri-Sun-Smith drainage, consuming an estimated 295,000 acre-feet annually. Much of this irrigation has been developed privately, but several projects have been developed by federal and state agencies. There are 17 reservoirs and run-of-river impoundments within the basin having at least 1,000 acre-feet of storage each. The three largest are Canyon Ferry and Holter, both on the Missouri River, and Gibson on the Sun River.

Water quality in the basin runs the gamut from the best to the worst in the state. There are 16 municipal, 8 agricultural, and 28 industrial discharges in the Missouri-Sun-Smith basin. However, even with the application of best practicable and secondary treatment to industrial and municipal discharges, respectively, not all waters in the basin will meet state water quality standards. Such water quality limited stream segments include portions of Muddy Creek (near Vaughn), Sun River, Missouri River, Sand Coulee Creek, Dry Fork Belt Creek and Belt Creek.

The Missouri-Sun-Smith basin includes five hydrologic units:

Upper Missiouri River (10030101) and Lower Upper Missouri River (10030102).

The Missouri is formed by the confluence of the Madison, Jefferson and Gallatin Rivers near Trident, Montana. Water quality in the river is a composite of these tributaries. From Trident to Fort Benton, the Missouri undergoes several water quality changes. Contributing to this transition are three major impoundments, numerous discharges of municipal and industrial wastes, agricultural activities, a geological transition as the river leaves the mountains and enters the plains, plus inflow of three large tributaries. As a result of these factors, the river changes from a salmonid fishery above Great Falls (B-D_1) to a warm-water fishery at Fort Benton (B-D_3).

The river is a hard, calcium bicarbonate water with lesser concentrations of magnesium, sodium, sulfate and chloride. Canyon Ferry Reservoir is serving as a sink for iron, indicating a general lack of anaerobic conditions at the water-sediment interface. Because of near-bottom withdrawals, Canyon Ferry does not serve as a nutrient trap. Iron and zinc concentrations are significantly higher below Great Falls than above. Increased iron concentrations originate from the Sun River. Increased zinc concentrations probably are due to industrial discharges from the Anaconda Company, Great Falls. Turbidity increases have been noted below Great Falls and are due to high sediment loads carried by Muddy Creek and the Sun River. Past discharge of poorly chlorinated primary effluent from the Great Falls municipal sewage treatment plant has been the probable cause of high coliform densities at Fort Benton. Moderate arsenic and fluoride levels in the river are derived

from Yellowstone Park thermal springs. Typical fluoride concentrations entering Canyon Ferry Reservoir are 1.2 mg/l and vary from 0.95 mg/l to 1.4 mg/l. Fluoride levels near Great Falls vary from 0.17 mg/l to 1.0 mg/l. Arsenic levels are not toxic but exceed those known to be carcingenic.

Sixteenmile Creek is one of the first high quality tributaries to enter the Missouri in this basin. Summertime flows at Ringling are small, averaging about 1 cfs. The water here is hard, sodium bicarbonate type with some iron. Turbidities of 2 JTU or less are an indication that upstream agricultural activity is not significantly affecting water quality. However, poor irrigation practices along Hay, Faulkner and Battle Creeks result in high sediment loads in Sixteenmile Creek downstream of Ringling. Summertime flows near the mouth at Lombard average about 30 cfs. Significant input of high quality, calcium bicarbonate water from the Madison Formation occurs in this canyon region, resulting in the higher flows and a calcium bicarbonate type of water. Sixteenmile Creek is classified B-D_1 (B-1).

Crow Creek rises in the Elkhorn Mountains and flows in an easterly direction to the Missouri River at Toston. Upstream of the USGS station near Radersburg, Crow Creek is a pristine mountain stream little affected by the logging, livestock grazing, recreation and mining activity occurring in its watershed. Water here is a calcium-bicarbonate type with low turbidity and low sodium, chloride, and sulfate concentrations.

Extensive agricultural development in the Crow Creek drainage between Radersburg and the Missouri River has a major effect upon stream-flows and water quality. Crow Creek near its mouth is a moderately turbid, calcium-bicarbonate, very hard water with significant amounts of sodium, chloride and sulfate. Natural streamflows in lower Crow Creek are erratic during summertime but are augmented by the Crow Creek Pumping Unit, which supplies irrigation water from the Missouri River. Crow Creek is classified B-D_1(B-1).

Prickly Pear Creek heads in the mountains south of Helena and flows north for about 14 miles before reaching the Helena Valley. It then continues north for 12 miles across the valley before being joined by Tenmile Creek. Prickly Pear Creek terminates at Lake Helena two miles downstream from the confluence with Tenmile Creek. The stream has suffered and continues to suffer many abuses. Placer mining, construction of highways and railroads and industry have obliterated most of the original channel upstream of East Helena, Montana. The creek also is subject to heavy metals pollution from abandoned mines and extensive dewatering for irrigation.

Prickly Pear Creek near Clancy is a moderately hard, calcium-bicarbonate water with lesser amounts of sodium and sulfate. Moderate iron, zinc, lead and copper concentrations are attributed to drainage from inactive mines in the Corbin and Wickes area. Total coliform density and nutrient concentrations are low.

Prickly Pear Creek near its mouth has been seriously degraded by the city of Helena's discharge of poorly treated sewage. Recent improvements in Helena's treatment facilities have significantly improved the condition

of Prickly Pear Creek, although instream ammonia levels are still toxic. Upper Prickly Pear Creek above East Helena is classified B-D_1 (B-1). Below East Helena, Prickly Pear Creek is classified E-F (E), largely because of dewatering for irrigation.

The Dearborn River begins in a primitive mountain area on the east flank of the Continental Divide. Most of this area is unroaded and water quality is good. After leaving the mountains, the Dearborn flows easterly through broken grazing land to the Missouri River near Craig, Montana. It is generally an isolated stream, crossed only occasionally by state, county and private roads.

Water quality of the Dearborn remains essentially unaltered to near Craig. However, a significant input of sediment has been observed between Craig and the river's mouth. Irrigation return flows from agricultural lands in the Flat Creek drainage are the suspected source. Also, there has been considerable disturbance of lands adjacent to the Dearborn River near its mouth. This land has been subdivided and is being developed for second homesites. The Dearborn River is classified B-D_1 (B-1).

Other streams in this hydrologic unit except those specifically identified above, are classified B-D_1 (B-1) or better.

Smith River (10030103).

The Smith River is formed by the confluence of its north and south forks four miles southwest of White Sulphur Springs. After flowing northwest for about 25 miles, the river enters a narrow mountain canyon. Upon leaving the canyon, the river meanders through a relatively narrow agricultural valley flanked by rolling grasslands. It joins the Missouri River at Ulm about ten miles southeast of Great Falls. Numerous high quality tributaries join the river along its length. Farming, ranching, and logging are the predominant activities in the drainage.

The Smith River to the mouth of the canyon is an excellent quality stream, except for occasionally high temperatures. Turbidity increases below Hound Creek are due to channel erosion accelerated by agricultural activity. Waters in the Smith River drainage are classfied B-D_1 (B-1) or better.

Sun River (10030104).

The Sun River originates on the east slope of the Continental Divide near Augusta. Few roads penetrate this headwaters region, which includes part of the Bob Marshall Wilderness Area. East of the mountains, the Sun River and its tributaries are developed extensively for irrigation; thus, summertime flows are erratic. Concentrations of major chemical constituents increase downstream. Changes in geology, and the addition of tributaries and irrigation return flows are the causes. Turbidities are low downstream to Fort Shaw. Between Fort Shaw and the USGS station below Muddy Creek the Sun River experiences a dramatic increase in suspended solids. Muddy Creek discharges a heavy sediment load to the Sun River at Vaughn.

Soil erosion is the major problem in the Muddy Creek drainage. Approximately 200,000 tons of soil per year are eroded and transported to the Sun River. Unstable soils and abnormally high flows caused by excess irrigation water being returned to Muddy Creek are major factors. The lower reach of Muddy Creek is in serious condition with a degrading channel and 5 to 15 foot vertical banks. Upper sections of Muddy Creek have some erosion but generally are stable. Moderate nitrate levels also are present in Muddy Creek. Concentrations measured at Power ranged up to 8.8 mg/l NO_3. Similar nitrate levels were measured near Vaughn. Waters of the Sun River drainage are classified $B\text{-}D_1$ (B-1), except for Muddy Creek, which is classified E-F (E), and the mainstem Sun River below Muddy Creek, which is classified $B\text{-}D_3$ (B-3).

Belt Creek (10030105).

Headwaters of Belt Creek are in the Little Belt Mountains southeast of Great Falls. Portions of the Little Belts drained by Belt Creek are highly mineralized and have been sites of mining activity since the 1800's. Flowing south to its junction with the Missouri River, Belt Creek is paralleled by U. S. Highway No. 89 for about half its length. Summer home and camp development along the stream has been popular with Great Falls residents for many years. Belt Creek leaves the Little Belts and enters a narrow foothills valley at Riceville. The valley widens at Belt where extensive coal deposits have been worked sporadically since 1876.

Upper Belt Creek near Neihart has moderately-hard, calcium-bicarbonate water with low sulfate, chloride, magnesium and sodium concentrations and low turbidity. Metal concentrations near Neihart generally are low because mining activity has been very slight in this segment of the Belt Creek drainage and no acid mine seeps are known. Lower in the drainage, metals concentrations near Monarch are significantly higher than those near Neihart. Carpenter Creek, site of the Montana Mining District, enters Belt Creek below Neihart and is the probable metals source. The Dry Fork of Belt Creek, which joins Belt Creek at Monarch, has been degraded severely by acid mine drainage from the Hughesville-Barker area. Belt Creek below Riceville loses much of its flow to channel seepage and often is dry just above its confluence with Otter Creek near the town of Belt. Seeps from inactive coal mines near Belt contribute additional acid mine drainage to Belt Creek. All waters in the Belt Creek drainage are classified $B\text{-}D_1$ (B-1) or better. Below Otter Creek, the mainstem Belt Creek is classified $B\text{-}D_2$ (B-2), although streams tributary to this reach are classified $B\text{-}D_1$ (B-1).

d. Marias River Basin

The Marias River Basin heads near East Glacier Park and drains a rolling agricultural area in northcentral Montana to the mouth of the Marias and Teton rivers on the Missouri River below Fort Benton. The basin drains approximately 9,100 square miles, including about 580 square miles of dry lake beds. Drainage in the area is poorly developed and does not contribute significant water yields or peak flood flows.

The basin varies from rugged mountains along the Continental Divide on the west to broad, rolling plains broken by buttes in the southcentral part of the basin and by the Sweetgrass Hills in the northern part. Dominant geographical features include Tiber Reservoir in the eastcentral portion and the mountains of the west, which encompass the southeast part of Glacier National Park. There is an abrupt transition from the mountains to the plain stretching to the east, with little foothill development.

Climate of the Marias basin is characterized by short, hot and dry summers and cold, dry winters. A large portion of the annual precipitation occurs in the spring. Precipitation ranges from 10 to 30 inches per year, with better than 30 inches falling in the mountains. Mean monthly temperatures range from -2°F in January to 83°F in July. Wind is a persistent feature of the basin's climate; frequent warm, dry chinook winds may cause rapid snowmelt and flooding.

Soils in the basin are highly variable, with some presenting moderate to severe erosion hazards when disturbed. About 62 percent of basin lands are used for pasture and range. Croplands comprise 31 percent of the total area; 2 percent is under irrigation and 29 percent is dryland. The major irrigated crop is hay, which is used for summer pasture as well as winter feed. Forest and woodlands occupy the remaining 7 percent of the basin. Oil and gas production occurs throughout the basin. The urban population is small; only about 15,000 people live in the nine largest communities.

The largest water feature in the basin is Tiber Reservoir, with a capacity of 1,368,000 acre-feet. There is a total of 11 reservoirs in the basin with a capacity of 1,000 acre-feet of storage or more. Of these, nine are used for irrigation. Irrigated agriculture is the largest water user in the basin. Annual diversion requirements for irrigation are approximately 780,500 acre-feet. Of this amount, about 191,200 acre-feet is consumed and 176,800 acre-feet is lost in the system; about 412,500 acre-feet of the diverted water is return flow. Municipal and industrial water use in the basin is negligible. Most streams in the western part of the basin are perennial. Many of the naturally perennial streams elsewhere in the basin are no longer so because of irrigation water diversions and consumption.

Water quality in the mainstem of the Marias and in the area's western portion is good to excellent while the water of tributaries and springs on the plains ranges from fair to poor. Water quality in each of the basin's five hydrologic units is discussed below:

Two Medicine Creek (10030201).

Two medicine Creek is the largest tributary to the Marias River, contributing approximately one-third of the river's flow. The creek's headwaters, which extend for approximately 45 miles along the Continental Divide, include Dupuyer Creek, Birch Creek, Blacktail Creek, Whitetail Creek, and Badger Creek, as well as upper Two Medicine Creek. The Two Medicine Creek drainage is essentially two drainages since Birch Creek discharges to Two Medicine near the mouth.

Two Medicine Creek near Browning is of excellent quality. Between Highway No. 89 and Highway No. 358, approximately 30 river miles, the quality of Two Medicine Creek changes significantly. Increases of TDS and hardness are probably due to plains tributaries or seeps. Turbidity is a major problem on lower Two Medicine Creek due to irrigation return flows from the Badger-Fisher main canal. Water in the canal flows from Badger Creek and discharges to Two Medicine Creek above Highway 358. This sediment is carried downstream for 70 miles before it settles out in Tiber Reservoir. Seven miles below the Highway No. 358 bridge Two Medicine Creek is further degraded by Birch Creek.

Observations have revealed excessive turbidity in Birch Creek as a result of the Badger-Fisher main canal.

All waters in the Two Medicine Creek drainage are classified B-D_1 (B-1) or better except Two Medicine Creek from Badger Creek to Birch Creek, which is classified B-D_2 (B-2).

Cut Bank Creek (10030202).

Cut Bank Creek is formed in a small headwaters area of Glacier National Park. Small irrigation plots are under development on the mainstem of Cut Bank Creek and on Willow Creek. A major irrigation project on the Seville Bench west of Cut Bank uses water from Two Medicine Creek and wastes water to Cut Bank Creek. Oil exploration and pumping occurs in the east part of the drainage, including Seville Bench, Rocky Coulee and Old Maid Coulee areas. Samples from Cut Bank Creek at Cut Bank have revealed high phenol concentrations, an indication that petroleum products have been seeping or spilling into the creek. Waters in the Cut Bank Creek drainage are classified B-D_1 (B-1) or B-D_2 (B-2).

Marias River (10030203).

The Marias River is formed at the confluence of Two Medicine Creek and Cut Bank Creek. The river flows approximately 50 miles before discharging into Tiber Reservoir and again for 68 miles after leaving Tiber Reservoir before discharging into the Missouri River. Major tributaries of the Marias River are Shultz Coulee, Medicine Rock Coulee and the Dry Fork of the Marias River above Tiber Reservoir, Willow Creek into the reservoir and Pondera Creek, Dugout Coulee, Cottonwood Creek, Black Coulee and the Teton River below Tiber Dam.

Data show that the concentrations of constituents increase downstream with much of the change occurring between Cut Bank and Shelby. This change is probably a result of inflows from poor quality streams and from geological change as the river crosses Colorado Shale. Streams entering the Marias River above Tiber Reservoir are of very low quality.

Schultz Coulee is a lowland drainage which discharges to the Marias River from the south approximately 20 miles northwest of Conrad. Included in its drainage are Valier and a large portion of the Pondera County Canal and

Reservoir Company's irrigation district. The coulee is used by this irrigation district as a drainage to return used water to the Marias River. Flow regulation has a very noticeable effect upon the sediment concentration in Shultz Coulee.

Hilger Coulee is a lowland drainage which discharges to the Marias River from the south, seven miles south of Shelby. This is extremely poor quality water probably resulting from highly alkaline groundwater seeping into the stream.

Suspended sediment is a major concern in the Upper Marias. This high sediment load is probably due in part to an unstable stream bed, but irrigation return flows from the Badger-Fisher Main Canal (see Two Medicine Creek) and the Pondera County Canal and Reservoir Company add significantly to the problem.

The Dry Fork of the Marias River has its headwaters in the hills near Rockport Colony west of Pendroy. The river flows generally northeast through irrigated farmland, pastureland, and occasional oil drilling operations. The Dry Fork of the Marias River is one of the poorest quality perennial streams in the Marias area. High values of TDS, total hardness, and common ions have been recorded in the Dry Fork including the highest concentrations in the Marias drainage for calcium, magnesium, sulfate, and nitrate. Some of these high values may be due to a change in geology as the stream enters the Cretaceous Shales or may be a result of poor quality ground water seepage, or a combination of the two. Such seepage increases during irrigation, possibly aggrevating water quality problems.

Little Dry Coulee, which discharges to the Dry Fork of the Marias River, contains the Conrad sewage discharge. This coulee has had a concentration of total ammonia that is toxic to fish. The water is diluted when discharged to the Dry Fork but probably still is toxic to fish for a short distance downstream.

All waters of the Marias drainage are classified B-D_2 (B-2), except a portion of the Dry Fork of the Marias River, which is classified B-D_3 (B-3).

Willow Creek (10030204).

Willow Creek is an intermittent stream that forms the north arm of Tiber Reservoir. No large towns are included in the basin and the only potential source of water quality problems are oil drilling operations near Ferdig. Waters in the Willow Creek drainage are classified B-D_2 (B-2).

Teton River (10030205).

The Teton River drainage involves more area than any of the Marias River tributaries, occupying approximately one-fifth of the Marias basin. Included in the drainage are the communities of Choteau, Dutton and Miller Colony (Hutterite religious colony). Land use varies from forestry in the western section, irrigated farming in the central portion, and dryland farming in the eastern section. The only discharges that reach surface waters are from the Choteau sewage lagoon and the Priest Butte Lake aquaduct.

Above Choteau, the Teton River and Deep Creek are adversely affected by irrigation withdrawals. Deep Creek is periodically dry at Highway No. 287 due to irrigation diversions, and the Teton River is periodically dry below the Bynum and Eureka diversions. Some of this diverted water is returned to the Teton River between Choteau and Collins. The Teton River has been channelized above Choteau in an effort to alleviate flood problems. The combination of water withdrawals and stream channelization has significantly decreased the amount of aquatic life in the river near Choteau.

Water quality in the Teton River is good to excellent in the headwaters but is degraded significantly by the time is reaches Collins. Between Collins and Loma, no appreciable change in water quality occurs except for increases in heavy metal concentrations. The greatest change in water quality occurs between Choteau and Collins. This change is probably due to the discharge of streams that carry irrigation wastewaters and to geological effects as the river crosses the Colorado Shale.

Waters of the Teton River drainage above Choteau are classified B-D_1 (B-1). The remaining waters in the Teton drainage are classified B-D_2 (B-2).

e. Middle Missouri River Basin

The Middle Missouri River Basin has as its axis the 275 miles of the Missouri River that flows generally eastward from Fort Benton, Montana, to the Fort Peck Dam.

The uppermost third of the river is bounded by rolling, relatively roadless farmland broken by the spectacular and rugged white cliffs of the Missouri River Breaks about 50 miles below Fort Benton. The Bear Paw Mountains loom to the north. The middle stretch flows under the only bridge between Fort Benton and Fort Peck Dam and into the Charles M. Russell Wildlife Refuge where cattle and wildlife graze on rough, prairie topography. The lower third of the basin encompasses the sprawling Fort Peck Reservoir, which is surrounded by the refuge and a general "badlands" topography.

Other than the Bear Paws, mountainous areas in the basin occur in the southwestern part near Lewistown and in a small uplift near Zortman. Rocks in these uplifts are mostly sedimentary, but include some igneous. Throughout the remainder of the basin, bedrock formations of sedimentary origin are exposed. The basin's history includes long periods of sedimentation, then erosion, regional uplifting, warping and glaciation.

Soils in the basin vary greatly. Along the major watercourses are rough, broken lands with clay soils that are less than 20 inches down to shale. Numerous shale outcrops occur. These soils present a severe erosion hazard.

The basin is typified by low annual rainfall and temperature extremes. Annual precipitation averages between 11 and 15 inches, with June the wettest month. Snowmelt from the minor mountain ranges that dot the area add to tributary flows between April and June.

The Middle Missouri Basin does not function as an integral economic area. The only major population center is Lewistown, with fewer than 10,000 residents. The western part of the basin has a greater percentage of grain-growing land, the east has more rangeland. Privately-owned range accounts for the largest land use in the basin.

The largest water use in the basin is for irrigation, diverting approximately a quarter-million acre-feet annually. Municipal water use accounts for about 5,000 acre-feet annually.

The basin has substantial energy resources in the form of petroleum and coal. There is continuing petroleum exploration and production, but it has had little impact on water quality. There are, however, substantial deposits of strippable coal on the southern and eastern portions of the basin. These have yet to be developed, but plans are in the wind for coal mining and synthetic fuel production in the area.

The basin contains five municipal and two industrial dischargers and several feedlots. However, sediment is the dominant spoiler of the basin's water, particularly in Arrow Creek, Judith River and Missouri River. This pollutant emanates from irrigation returns, poor soil conservation practices,

overgrazing and natural erosion. Segments of Arrow Creek, Coffee Creek and Wolf Creek have been designated as water-quality limited due to excessive concentrations of sediment and dissolved minerals.

Nutrient concentrations, particularly nitrate and phosphate, have been observed in Beaver, Casino, Boyd, Little Trout, Cottonwood, Ross Fork and Arrow Creeks.

The Middle Missouri River Basin contains six hydrologic units:

Middle Missouri River (10040101) and Fort Peck Reservoir (10040104). Water quality problems are associated with nutrients, sediment and salt, which combine to give the river and reservoir a B-D_3 (B-3) classification from Great Falls all the way to Fort Peck Dam. The major problem lies with the river's tremendous sediment load. Data collected at the Fred Robinson Bridge (near the arbitrary point where the Missouri River becomes the Fort Peck Reservoir) show that during the months of March and May the largest sediment loads were 150,000 and 800,000 tons per day, respectively. Phosphorus levels have been high enough in the area near the bridge to encourage algal blooms--but no nuisance blooms have been reported.

Four miscellaneous creeks flowing into the Middle Missouri and reservoir show saline tendencies. They are Dog, Bullwhacker, Two Calf and Big Dry Creeks. High iron, sodium and sulfur values tend to make these creeks unpalatable.

Arrow Creek (10040102). Arrow Creek originates in the Highwood Mountains near Geyser and flows northeasterly approximately 60 miles to its confluence with the Missouri River. The upper reaches (at Highway No. 230) are fair quality waters; however, from Highway No. 230 to its mouth the creek is water quality limited. According to a schematic by the U.S. Salinity Lab, these waters would be high in salinity hazard and should not be used for irrigation. The tremendous silt loads carried by this stream comprise a large portion of the silt load in the Missouri River.

Periphyton analysis of this stream shows an unusual flora with alkaline affinities. This stream is definitely an anomaly in the Middle Missouri area.

Concentrations of suspended sediment and salinity, particularly downstream from Highway No. 230, are high enough to seriously inhibit aquatic biota resulting in low and unusual periphyton populations and very low benthic populations. Arrow Creek has the same B-D_3 (B-3) classification as the Missouri at their confluence.

Judith River (10040103). The Judith River from Big Spring Creek to its confluence with the Missouri is classified as B-D_2 (B-2), and from Big Spring Creek to its headwaters it is listed as a B-D_1 (B-1) stream. The entire stream is basically a calcium bicarbonate water of good quality.

The Judith has nitrate values that indicate enrichment, which leads to excessive aquatic growths. Measured suspended solids were high near Hobson and at the mouth. Headwaters silt loading may be from poor logging practices, agricultural procedures and subdivisions. The silt load at the mouth represents the cumulative effect of these cultural activities.

Periphyton analysis at the mouth demonstrates the impact of turbidity. Periphyton populations are small in this stream segment and those periphyton present reflect an excessive sediment load and concentration of nutrients.

Depressed trout and benthic populations downstream of Hobson indicate water quality problems, probably due to excessive silt loads. High coliform counts also have been observed, but not in excess of water quality standards.

Big Dry Creek (10040105). Big Dry Creek flows into the Big Dry Arm of Fort Peck Reservoir. Big Dry waters, classified B-D3 (B-3), are of the sodium sulfate type and are a result of the naturally saline soils being drained by this stream.

Little Dry Creek (10040106). The Water Quality Bureau has collected no information on the water quality of Little Dry Creek, which flows into the Big Dry a few miles south of Fort Peck Reservoir. The Little Dry does drain soils similar to those in the Big Dry drainage and is also classified B-D3 (B-3).

f. Musselshell River Basin

The Musselshell River originates at the confluence of its North and South Forks east of Martinsdale, Montana. From its origin in the Little Belt Mountains, the river flows in an easterly direction for 125 miles along the southern flank of the Big Snowy Mountains. The river then flows northward for 55 miles to Fort Peck Reservoir. The river and its tributaries drain an area of approximately 8,000 square miles.

The basin terrain generally may be described as hilly to moderately sloping. Soils in the basin are as varied as the physiographic features. The valley of the Musselshell, which contains the basin's more desirable farmland, averages less than a mile wide and is bordered by sandstone rimrocks and rugged shaly breaks along most of its course. Soils that have developed in these eroded lands are generally loamy to clayey in texture and less than 20 inches deep. These soils present a high erosion hazard and contribute to the sediment load of the river. Many of the basin's heavier-textured soils are deep and have a high moisture-holding capacity, but also accumulate salts. Some terraces in the western portion of the basin have loamy soils that are highly calcareous.

The Fort Union coal formation is present in the central portion of the basin near Roundup. The formation contains commercial coal beds under development southeast of Roundup.

The Musselshell Basin is best described as a semi-arid region with a short growing season. Average annual precipitation is around 12.5 inches. Forty to fifty percent of that falls in the spring, with June the wettest month. The various mountain ranges contribute some snowmelt runoff.

The basin is definitely rural. There were only 9,446 people living there in 1970, and that number was expected to decline by at least 1,000 people by 1980.

The largest land use within the Musselshell Basin is privately-owned rangeland, comprising 67 percent of the basin. Irrigation is the basin's largest water consumer, diverting nearly one-half million acre-feet annually. Municipal water use in the basin accounts for only 114 acre-feet per year.

One industrial use that had a great impact on the Musselshell River itself was the building of the Milwaukee Railroad. Placement of the railroad bed along the river and associated diversions resulted in the straightening of the river and removal of some oxbows. Faster flows, greater erosion, warmer temperatures and loss of fishery habitat all contributed to the slow decay of the Musselshell since the early 1900s. The financial collapse of the Milwaukee Road in the late 1970s leaves even the maintenance of a decent railroad bed in doubt.

Water quality problems in this basin are predominately nonpoint-source oriented, stemming from three broad categories: logging, agricultural and natural. Some saline seep occurs in the area. As we shall see in the following examination of the basin's five hydrologic units, the quality of Musselshell

water becomes more and more degraded, mainly by sediment, as we travel east and north toward Fort Peck Reservoir.

Upper Musselshell (10040201). The North and South Forks of the Musselshell River are waters of fine quality, both being hard, calcium-bicarbonate streams. Nitrate and phosphate concentrations tend to increase during the peak of the irrigation season. Nutrient concentrations are sufficient to cause seasonal stream enrichment.

At Harlowton, the stream's flora reflect a moderate salinity and nutrient enrichment, probably the result of irrigation return water. Water quality in the Upper Musselshell ranges from B-D_1 (B-1) to C-3 in the lower reaches.

Middle Musselshell (10040202). By the time the water reaches Roundup, it's much different than that found at Harlowton. The river changes to a sodium-sulfate type water with increased sediment loads, turbidity and higher specific conductance. These changes are due to natural terrain, irrigation returns and the influx of poor-quality tributaries like Antelope Creek and Mud Creek. Mainstem classification from near Roundup to near Mosby is C-3.

Lower Musselshell (10040205). The Lower Musselshell is unlike the upper two areas. The river is warmer, shallower, saltier and carries excessive sediment, mainly due to geology, topography and irrigation returns. Concentrations of dissolved solids increase downstream of Roundup. So does the sodium absorption ratio (SAR). These parameters continue to increase downstream to Mosby. Nitrate concentrations attain their highest levels at Mosby. Nitrate and dissolved solids concentrations significantly inhibit usage of these waters. Fecal coliforms in excess of state standards have been observed at Musselshell and Mosby. The lower Musselshell mainstem's classification, from near Mosby to Fort Peck Reservoir, is B-D_3 (C-3).

Flatwillow Creek (10040203). Originating in the Big Snowy Mountains, Flatwillow Creek begins as a calcium-bicarbonate water and ends as a sodium-sulfate water, due to geology, irrigation returns and salt accrual in Petrolia Reservoir. Sediment is a major pollutant, especially in spring months. During August, because of high salinity, waters of the lower Flatwillow are unfit for irrigation. Flatwillow Creek is classified B-D_2 (B-2 to Highway 87, then C-3 downstream).

Box Elder Creek (10040204). This stream drains about 16.2 square miles and is a sodium-sulfate water. Alkalinity, high dissolved solids and a high SAR renders this stream undesirable for irrigation. Again, this stream's salinity is attributed to natural geology, possibly aggravated by dryland farming practices. It is classified B-D_3 (C-3).

g. Milk River Basin

The Milk River Basin, includes the Milk River, which originates in Glacier National Park, extends into Canada, re-enters the U.S. and extends eastward to its confluence with the Missouri River below Fort Peck Dam. The basin drains about 15,000 square miles from altitudes of over 7,000 feet in the peaks of Glacier Park at its western end to 2,000 feet at its eastern end.

The major geologic event that influenced soils of the Milk River Basin was the advance and recession of the continental glacier. Glacial deposition and extensive sedimentation over long periods of time have resulted in the filling of many stream valleys with alluvium. Bearpaw Shale, Judith River Sandstone and Claggett Shale are exposed over large areas.

From one section of the basin to another, soils vary enough from having a moderate erosion potential to a high erosion potential. Dominating much of the undulating to nearly level glacial plains north of the Milk River are soils with a highly alkaline layer that restricts plant growth, giving these soils a desolate appearance. These soils have poor drainage and a high erosion hazard, and are judged poor for irrigated crop production.

The exception to the general glaciated pattern north of the Milk River is the area north of Harlem known as the "Big Flat." It has well-developed, loamy textured soils that overlay clay-loam glacial till. The soils of the "Big Flat" present slight to moderate erosion hazards and generally are used for dryland grain production.

Greatly varying topography plays a large part in the basin's climate pattern. Winter chinook winds are prevalent in the extreme western portion, raising temperatures from below zero degrees F to above freezing in a very short time. Portions of the basin to the east have a typical continental-type climate of cold, dry winters; cool, moist springs; and warm summers. The mean annual precipitation for the basin is about 12 inches, most of which falls in early summer.

The Milk River Basin encompasses much of the northern string of Montana counties known as "The Highline." In 1970, 40,000 people lived in the basin--projected to increase by 2,000 by 1980. Havre, the largest city with well over 10,000 residents, sits in the center of the basin. Glasgow, with about 5,000 residents sits at the east end of the basin, and there are three other communities in the basin with around 2,000 residents each.

The largest land use in the basin is privately-owned range land, constituting about 45 percent of the total basin. The next largest is federal non-crop, which includes all federal lands in the basin that are not being farmed. This accounts for about 28 percent, the majority being used for range land. Cropland takes up about 22.9 percent, mostly as dryland grain production in the western half of the basin.

Irrigation is the largest water user, diverting about 1.5 million acre-feet annually. Municipal water use accounts for about 5,000 acre-feet per year. Industrial water use is negligible, but there are several industrial and agriculture waste discharges and at least a dozen municipal waste discharges.

There are oil, natural gas, and coal deposits in the basin with an increase in exploration and production expected.

Nonpoint-source pollutants are the major despoilers of Milk River Basin waters. The sources: agricultural wastes and fertilizers, erosion and sediment from poor grazing and cropping practices and construction projects, logging, toxic substances, and saline soil.

The Milk River Basin is divided into 16 hydrologic units:

Milk Headwaters (10050001). The North and South Forks of the Milk River, beginning on the eastern slopes of Glacier National Park, are calcium-bicarbonate waters of excellent quality. The upper portions of each fork and their tributaries are generally unaffected by mining, agriculture and logging, but the South Fork flows across several large ranches that pasture livestock as its exits the park. Snowmelt from the Rocky Mountains and irrigation diversion make for great variations in flow. The drainages of the two forks are classified B-D_1 (B-1).

Upper Milk (10050002). After flowing through Canada for about 150 miles, the Milk River enters the U.S. about 30 miles northwest of Gildford, Montana. Its flow is then southeast to Fresno Reservoir and then to Havre. Flows are regulated by Fresno Dam with peak discharges in May, June and July, corresponding to maximum irrigation demand. Considerable farming occurs along the upper Milk, but no adverse impacts have been recounted. The upper Milk mainstem is classified B-D_3 (B-3).

Wild Horse Lake (10050003). This unit is due north of Fresno Reservoir and against the Canadian border. However, water-quality data are not available.

Middle Milk (10050004). This section flows easterly from Havre to near Malta. Havre, Chinook, Harlem and Malta all discharge wastewaters of various qualities into the Milk. There is extensive irrigation along this portion of the river and water quality is degraded by streambank erosion, irrigation runoff and occasional dead animals. Some citizens use the river to dump lumber and old cars and machinery. The lower portion of this segment has been found to be a calcium-bicarbonate type of water. The Middle Milk mainstem is classified B-D_3 (B-3).

Lodge Creek (10050007) and Battle Creek (10050008). Both creeks begin as good quality, calcium-bicarbonate streams flowing from the relatively hilly terrain of Canada. Their flow and quality are affected by agricultural grazing and irrigation practices. In Canada, both streams have storage reservoirs. The creeks have B-D_3 (B-3) classifications.

Cottonwood Creek (10050010). This creek flows into the Milk River just northwest of Malta. No water-quality data are available. It would fall under the B-D_3 (B-3). classification.

Big Sandy Creek (10050005). Originating in the Bearpaw Mountains south of Havre, Big Sandy Creek begins with excellent waters that deteriorate on their downstream journey because of bank erosion and irrigation practices.

Near the mouth, Big Sandy Creek is a calcium-bicarbonate type water. The Big Sandy drainage above Big Sandy is classified B-D_1 (B-1); the remainder is B-D_3 (B-3).

Sage Creek (10050006). Classified B-D_3 (B-3), Sage Creek flows from near the Canadian border southeast to its confluence with Big Sandy Creek near Box Elder, Montana. No water-quality data are available.

Peoples Creek (10050009). Peoples Creek has minor branches originating in both the Bearpaw Mountains and the Little Rocky Mountains. Its flow is generally in a northeastward direction to its confluence with the Milk River. Most of the creek is on the Fort Belknap Indian Reservation and has been relatively undisturbed by mining, agricultural and logging practices. Most of the stream passes through grazing land, but the extreme lower portion is used to flood irrigate wild hay. The water quality of Peoples Creek is generally a good, calcium-bicarbonate type of hard water. It has been reported in the past that during exceptionally high runoff, leachates from mine tailings had increased arsenic concentrations to levels killing fish. The Peoples Creek drainage to and including the South Fork is classified B-D_1 (B-1). The remainder is B-D_3 (B-3).

Whitewater Creek (10050011). Another waterway spilling off the Canadian border, Whitewater Creek meets the Milk north of Saco. It is classified B-D_3 (B-3), but we have no confirming water-quality data.

Lower Milk (10050012). From Cottonwood Creek northwest of Malta, the Milk River flows generally eastward to its confluence with the Missouri. This segment is entirely in agricultural lands, and agricultural practices influence both the flow and quality of the river. Flows of this segment are affected by the Dodson diversion dam and are highest in July. The water of this stream segment is a calcium-bicarbonate type of hard water. This part of the Milk River is classified B-D_3 (B-3).

Porcupine Creek (10050016). Another calcium-bicarbonate stream, Porcupine Creek begins in the hilly land north of Glasgow. It flows southward through agricultural lands, mostly dryland farms, to its mouth at the Milk River. It is classified B-D_3 (B-3).

Frenchman River (10050013). Flows of the Frenchman River originating in Canada are controlled by a series of Canadian reservoirs. Water of this river in the U.S. is calcium-bicarbonate type hard water. The stream is of fair quality, as indicated by propagation of several fish species and a diversified aquatic ecosystem. Classification: B-D_3 (B-3).

Beaver Creek (10050014). Beaver Creek originates on the eastern slopes of the Little Rocky Mountains and generally flows northeastward to its mouth at the Milk River. Its course is primarily through agricultural land, but the Saco sewage lagoon also discharges into the creek. Flow data have not been collected on Beaver Creek, but it's speculated that snowmelt from the Little Rockies and irrigation practices would be the most significant factors influencing flow. The creek is a calcium-bicarbonate type hard water near its mouth. It is of fair quality as indicated by aquatic biota productivity and diversity. It is classified B-D_3.

Rock Creek (10050015). No water quality data are available. It is classified B-D_3 (B-3).

h. Lower Missouri River Basin

The Lower Missouri River Basin includes that portion of the Missouri River below Fort Peck Dam to the Montana-North Dakota boundary and associated tributaries. The basin has a total area of about 10,000 square miles with elevations from 3,500 feet in the Big Sheep Mountains to 1,900 feet along the eastern boundary. Topography varies between rolling hills and flat plains that are occasionally cut by stream valleys, sometimes forming badland-type pinnacles, bluffs and steep banks.

Except for the Redwater River drainage, this basin was highly glaciated. Soils range from farmable to non-farmable, from moderately erosive to highly erosive. The unglaciated Redwater River area is underlain by the Fort Union coal formation.

A continental type climate is typical for the Lower Missouri River Basin. Winters are cold, summers are warm, spring is wet. The three major weather producers are: arctic invasions during winter, active low pressure areas during spring, and summer thunderstorms. Precipitation amounts vary from 10 to 14 inches in the western portion to about 17 inches annually in the eastern portion. Although long-lasting snowdrifts can accumulate throughout the area, there are no significant mountainous areas that release a large amount of spring snowmelt.

The largest land use in the basin, according to 1967 figures, is privately-owned range land, which constitutes about 40 percent of the total land resources. The next largest is cropland at about 33 percent. Federal non-crop land, most of which is being used for grazing, makes up about 19 percent of the land area.

In 1970, 26,680 people lived in the basin. That's expected to rise by 1,000 people at most in the 1980 census. Only the town of Wolf Point, with its 3,000 residents, is classed as urban. Population projections haven't taken into account the vast deposits of strippable coal under the southern portion of the basin. Exploratory activity has increased and plans for development are under way.

For now, however, the largest water use in the Lower Missouri Basin is irrigation, diverting about 270,000 acre-feet annually. Municipal water use is a mere 3,000 acre-feet a year. Industrial water use is negligible.

Waters of the basin generally are of only fair quality, being high in sodium and sulfates and providing warm-water habitats. We shall examine each of the basin's seven hydrologic units:

Prairie Elk and Wolf Creeks (10060001). This encompasses a large drainage area north and south of the Missouri mainstem between Fort Peck Dam and the Poplar River. Prairie Elk Creek does not have enough flow to sustain game fish, although game fish use the stream for spawning. Several non-game forage fishes do populate the creek. Water quality in Prairie Elk Creek appears to be poor, but has not been documented. Wolf Creek, however, contains self-sustaining brook trout populations and rainbow trout are stocked. But Wolf Creek also suffers from inadequate flows and the slightest decline in water

quality would create unsuitable trout habitat. Prairie Elk Creek is classified (C-3) and Wolf Creek is classified B-D_2 (B-2).

Charlie Creek - Little Muddy Creek (10060005). These creeks are basically the same as Prairie Elk Creek mentioned above, but little water quality data exist. The unit would be classified (C-3).

Redwater River (10060002). Originating as intermittent stream drainages on the northern slopes of the Big Sheep Mountains, the Redwater River flows north and slightly east to the Missouri River. Along this course, agricultural activities consist mostly of grazing and dryland farming. The water is a calcium-bicarbonate type hard water, has a high specific conductance and is high in sodium, magnesium and sulfates. Water is generally of poor quality and is unsuitable for irrigation. Water quality of the Redwater River is classified (C-3).

Poplar River (10060003). The three forks of the Poplar originate in Canada, flow into the U.S. and merge on the Fort Peck Indian Reservation. The Poplar enters the Missouri at Poplar, Montana. Along these streams, most activities are grazing and dryland farming. The water is a sodium-bicarbonate type water with a high specific conductance. Limited sampling has indicated a high fecal coliform count. Water is of poor quality and is sometimes unsuitable for irrigation during summer months. Elevated levels of mercury have been detected in the waters recently. The potential effects of energy-development in Saskatchewan are now being debated and studied. The Poplar drainage is classified B-D_2 (C-3).

West Fork Poplar River (10060004). Water quality in the West Fork of the Poplar River is somewhat better than in the mainstem Poplar River. Nevertheless, the West Fork shares the mainstem's (C-3) classification.

Big Muddy Creek (10060006). Big Muddy Creek originates at the confluence of Beaver Creek and Whitetail Creek. Whitetail Creek begins as an intermittent stream in the rolling hills near the Canadian border. After merging to form Big Muddy Creek, the stream flows generally east to Plentywood and then generally south to the Missouri River. Along this course, agricultural activities include grazing and dryland farming. The water is a calcium-bicarbonate type hard water with a high specific conductance. Limited data indicate it to be high in fecal coliforms. Water quality is poor, being high in conductivity, bicarbonates, sodium, sulfates and metal. Downstream portions have better water quality due to groundwater infiltration, the influence of other streams, and other causes. The drainage is classified (C-3).

Brush Lake Closed Basin (10060007). Water-quality data are not available for this mini-basin located at the very northeast corner of Montana.

i. Upper Yellowstone River Basin

The Upper Yellowstone River Basin is located in the south central part of Montana. It encompasses the eastern slopes of the Rocky Mountains and the western edge of the Great Plains. The basin has a varied topography ranging from flat valley bottoms in the northeastern section to extremely mountainous country in the southwest portion.

Mountain ranges in the Upper Yellowstone River Basin are: Gallatin, Bridger, Crazy, Absaroka and Beartooth. Elevations in the basin range from 12,799 feet (Granite Peak--the highest point in Montana) to 3,300 feet (Yellowstone River Valley bottom near Laurel).

The Upper Yellowstone River Basin in Montana includes the Yellowstone River and all of its tributaries from the Yellowstone National Park boundary to just below the Clark's Fork of the Yellowstone.

The soils of the basin are as varied as the topography. The dominating features are broad, heavily-farmed and ranched stream valleys bordered by high, steep mountain ranges. Some soils have a high erosion hazard. Others, especially those heavily irrigated, show evidence of increased soil salinity.

The climate of the basin is generally of a continental nature, but there are several modifications in the area where the plains meet the mountains. The Clark's Fork Valley near Belfry is the driest part of the basin and one of the driest places in Montana. The average annual precipitation is only about six inches, due to the rain shadow effect of the Beartooth Mountains. The average annual precipitation for the basin ranges from those 6 inches up to about 35 inches. Most of the precipitation in the lower valleys and agricultural areas occurs during the growing season--April to September. Precipitation in the mountainous areas is fairly steady throughout the year. Spring snowmelt runoff has a drastic effect on streams in the basin.

The 1970 census showed that 109,412 people lived in the basin, with the city of Billings containing well over half of them, 61,000. Although there is a substantial amount of industry in the basin, including refineries along the Yellowstone River, agriculture is still the area's predominant economic activity.

About 30 percent of the basin is made up of forest land. Much of the basin offers recreational opportunities, including the Yellowstone River mainstem's 95 miles of "blue ribbon" trout fishing from the Yellowstone Park boundary to near the town of Big Timber.

The largest portion of the water used in the Upper Yellowstone River Basin is for irrigation, depleting almost 800,000 acre-feet per year. Municipalities take out only about 25,000 acre-feet a year. Large quantities of water are supplied to oil refineries, a Montana Power generating plant, and a sugar beet refinery.

Let's look at water quality in the six hydrologic units:

Yellowstone Headwaters (10070001). Little water-quality data are available. These are waters that originate within Yellowstone Park or in the high Absarokas within a few miles north of the park boundary. Classification of waters here is B-D_1 (B-1). Some are affected by acid mine drainage.

Upper Yellowstone (10070002). This unit takes in the Yellowstone mainstem from Gardiner to a point just downstream from the mouth of Sweet Grass Creek and includes several Yellowstone tributaries. The Yellowstone River here has relatively low concentrations of dissolved solids with a calcium-sodium-bicarbonate type of water. The water tends to become more calcium-bicarbonate as it moves downstream. Flouride was found to be one of the minor constituents of the river, probably a reflection of thermal discharges into the headwaters in Yellowstone Park. Waters in this stretch are rated an excellent B-D_1 (B-1).

Shields River (10070003). Water of the Shields River is non-saline while generally ranging from moderately hard to hard. Total hardness and dissolved solids in the Shields are slightly greater than those in the Yellowstone River. But the Shields does provide the requisite conditions for a cold-water fishery, although suspended sediment, turbidity and specific conductance are also higher than in the Yellowstone. It is a calcium-bicarbonate stream with better quality water upstream near Wilsall. Dissolved constituents increase as it moves downstream. The Shields River is classified B-D_1 (B-1).

Middle Upper Yellowstone (10070004). This section of the mainstem of the Yellowstone, from just below Sweet Grass Creek to Billings, hasn't changed much from the Upper Yellowstone stretch. There has been an increased amount of suspended sediments, slightly warmer temperatures, and increases in specific conductance. It is still classified B-D_1 (B-1) until it reaches Laurel, Montana, then is classified B-D_2 (B-2) to Billings. Most tributaries that enter in this stretch are of excellent quality.

Stillwater River (10070005). The Stillwater River drains the Absaroka and Beartooth Ranges. It and its tributaries are of a calcium-bicarbonate composition. In general, their waters are good to excellent quality. The only exceptions are those headwaters, just below mining operations, which feel the effects of acid mine drainage and sediment. Those waters recover fairly quickly as they meet waters from cleaner sources. The Stillwater River is well-suited as a trout stream. It is classified B-D_1 (B-1).

Clark's Fork of the Yellowstone (10070006). This drainage is somewhat unique for the Upper Yellowstone River Basin in generally having a poor to fair quality water. Three qualities can be distinguished within the drainage: (1) a good to excellent quality water in the Rock Creek drainage; (2) an intermediate, poor-to-fair quality water in the Clark's Fork mainstem, which has higher dissolved solids and larger suspended sediment loads than Rock Creek; and (3) a generally poor quality water in the remaining tributaries, several of which are sodium-sulfate, lowland creeks in contrast to the calcium-bicarbonate water of the two aforementioned arms of the Clark's Fork. This is reflected in the several classifications for the drainage; the Clark's Fork mainstem down to and including Jack Creek near Bridger is B-D_1

(B-1); the Clark's Fork from Jack Creek to the Yellowstone is B-D_2 (B-2); the West Fork of Rock Creek to Red Lodge is A-Open-D_1 (A-1); and the remainder of the Rock Creek drainage is B-D_1 (B-1).

j. Middle Yellowstone River Basin

The Middle Yellowstone Basin is on the western edge of the Great Plains. The basin is generally an area of rolling hills with gentle to moderate relief. The Bighorn Mountains spread into the southwest portion of the basin giving that area a steep, mountainous character. There are two portions of the Custer National Forest within the basin. The basin drains 10,600 square miles.

There are two Indian reservations within the basin, the Crow Reservation and the Northern Cheyenne Reservation.

The Middle Yellowstone Basin includes the Yellowstone River and all of its tributaries from the confluence of Pryor Creek at Huntley to the confluence of the Tongue River at Miles City.

Some of the soils of the basin, particularly on the flood plains, are somewhat poorly drained and have a high salt content. Soils on undulating to hilly sedimentary plains have slow to medium runoff and present slight to moderate erosion hazards. Soils on the rougher broken uplands have rapid runoff, present severe erosion conditions and have a high potential as sediment and salt sources to streams.

The mountains to the west and southwest of the Middle Yellowstone Basin create a moisture shadow, meaning the precipitation falls on those mountains before it reaches the basin. Sufficient snow falls in those mountains to give distinct runoff periods in the spring. Average annual precipitation for the basin is 11 to 16 inches, mostly falling in late spring and early summer.

About 75 percent of the basin's lands are used for pasture and range in the production of livestock. Forests occupy about 7 percent. Miles City (population 9,073), Hardin (2,733) and Forsyth (1,073) are the major population centers. Basin population in 1970 was 21,694.

More than 90 percent of the coal being mined in Montana comes from the Middle Yellowstone Basin, which contains a large percentage of the Fort Union strippable coal deposits in Montana.

Irrigated agriculture is the primary water user, depleting more than one-half million acre-feet per year. About a dozen towns use less than 5,000 acre-feet annually, and 85 percent of that is surface water.

Industrial use has been negligible, but increasing demands for water have been made by energy concerns, including power companies and coal-slurry pipeline corporations. Increased coal and energy production would also bring about a large increase in population. An entire town, the population of which could reach 3,000 by 1985, was recently approved by the state for construction near the Tongue River Reservoir.

The basin has 11 hydrologic units, but there is little water quality data on streams other than the Yellowstone, Bighorn and Tongue Rivers in the Middle Yellowstone Basin.

Lower Upper Yellowstone (10070007). This unit takes in the Yellowstone mainstem from Pryor Creek to the Bighorn River. Specific conductance and dissolved solids show a slight increase as the water moves through this stretch. This can be blamed on three tributaries, Pryor Creek, Arrow Creek and Fly Creek, all of which have distinctly larger concentrations of dissolved constituents, particularly sodium and sulfate, than the Yellowstone River. This unit is classified B-D3 (C-3). The Yellowstone here contains a few brown trout, but mostly has warmer-water forage fish.

Pryor Creek (10070008). Streams in this unit have been designated B-D_1. Pryor Creek, flowing northward out of the Pryor Mountains, is the principal stream. Sodium sulfate, chloride and total suspended sediment increase significantly in Pryor Creek as its water moves downstream. Water in the upper portion is basically a calcium-bicarbonate type, whereas in the lower portion, sodium, sulfate and occasionally chloride become prominent. The creek is partially dewatered by agriculture, but the effects aren't known. Upper reaches of the creek provide a cold-water fishery.

Bighorn Lake (10080010). Bighorn Lake, which reaches into Wyoming, was formed by the construction of Yellowtail Dam and is surrounded by the Bighorn Canyon National Recreation Area. Of the seven Montana creeks which flow into the reservoir, four have generally good quality water. They flow out of the Bighorn Mountains. But the remaining three streams, flowing from the Pryor Mountains, have higher concentrations of dissolved constituents. They are Dry Head, Hoodoo and Crooked Creeks. The lake supports both cold and warm-water fisheries. Water in the unit is classified B-D_1 (B-1).

Lower Bighorn (10080015). The Bighorn River drainage from Yellowtail Dam to but excluding Williams Coulee near Hardin is classified B-D_1 (B-1). The remainder of the river is classified B-D_2 (B-2) and its tributaries C-3. There's little variation of the flow in the Bighorn mainstem due to regulation by the dam. Tributaries have little apparent effect on the Bighorn inasmuch as concentrations of dissolved constitutents change little from the dam to the Yellowstone River. There is some increase in suspended sediments, possibly due to the combined effects of the tributaries. The Bighorn is an excellent trout fishing river from the dam to St. Xavier, where it becomes a warm-water habitat. This change is due primarily to an influx of sediment from Soap, Rotten Grass and Beauvais Creeks.

Shoshone River (10080014). No water quality data are available. Only a couple of minor tributaries drain Montana land.

Little Bighorn (10080016). The Little Bighorn River originates in the northeastern section of the Bighorn Mountains in Wyoming. It flows generally northward until its confluence with the Bighorn at Hardin. Besides the Little Bighorn, there are three other perennial tributaries of interest in this unit: Pass, Lodge Grass and Owl Creeks. These major tributaries, and especially some minor tributaries, are higher in specific conductance and dissolved solids than the Little Bighorn. This is most noticeable for sodium and sulfate. Pass Creek and Owl Creek are significant contributors to the suspended sediment loads in the Little Bighorn during high flows. Tributary creeks do have a significant effect on water quality in the Little Bighorn, especially on

dissolved constituents and suspended sediments. Above Crow Agency, the Little Bighorn is a good trout habitat. But silt and warmer temperatures change it to a warm-water fishery below Crow Agency. One tributary, Owl Creek, is not a suitable habitat for game fish due to large sediment loads. The Little Bighorn drainage above and including Lodge Grass Creek is classified B-D_1 (B-1). The remainder of the unit is B-D_2 (B-2).

Upper Tongue River (10090101) and Lower Tongue River (10090102). The Tongue River also originates in Wyoming's Bighorn Mountains and flows northeastward until it joins the Yellowstone River at Miles City, Montana. The Upper Tongue unit includes the river and its tributaries from the Wyoming border to Birney, Montana. About five miles into Montana, the Tongue becomes the Tongue River Reservoir. No tributaries enter in Montana above the reservoir. Three major tributaries downstream are Hanging Woman, Otter and Pumpkin Creeks. High specific conductance values showed up in all major and minor tributaries, where concentrations of common ions tended to be quite high. Sodium and sulfate concentrations in particular were high, but the concentrations of dissolved constituents tended to decrease as they moved downstream. Flow plays a big part in those concentration figures--the Tongue Reservoir dam does not regulate flows as much as, say, Yellowtail Dam on the Bighorn River. Average concentrations of common ions are generally higher for the Tongue River than for the Yellowstone at Miles City. The exception is chloride. A unique feature of the Tongue River is that on the average at low flow conditions the concentration of magnesium is larger than that of calcium. Biological conditions in the Tongue are generally good and it and its tributaries are a warm-water fishery. However, the river often carries an excessive silt load during the summer. From the Wyoming border to Prairie Dog Coulee, the Tongue River mainstem is classified B-D_2 (B-2). The remainder is B-D_3 (B-3), and other streams in the drainage are C-3.

Rosebud Creek (10100003). Rosebud Creek has as its source the Wolf and Rosebud Mountains, which have low altitude and low relief. The mountains are forest-covered but do not accumulate much snowpack. Flow in the lower portion of Rosebud Creek is more like a prairie drainage than a combined mountainous and prairie drainage. The unit is classified B-D_3 (C-3). As the water moves downstream through the unit, specific conductance, common-ion concentrations, and sediment all increase. A minor brook trout fishery is located in the upper reaches of Rosebud Creek, but habitat declines below Busby because of increased sediment loads.

Big Porcupine (10100002). This is the only hydrologic unit in the Middle Yellowstone Basin that drains into the Yellowstone River exclusively from the north. Big Porcupine Creek meets the Yellowstone a few miles upstream from Forsyth, Montana. Water quality data are not available. The unit is classified B-D_3 (C-3).

Lower Yellowstone-Sunday (excluding Sunday Cr.)(10100001). This unit centers on the Yellowstone River mainstem from the Bighorn River to about Miles City. The general increase in common-ion concentrations as the water moves downstream is more pronounced after the Yellowstone meets the Bighorn. It can be said, generally, that all tributaries along this stretch degrade the Yellowstone to some degree. High flows of the tributaries do not usually coincide with high flows of the Yellowstone, so even minor streams may

collectively have a significant degrading effect on the Yellowstone. The Bighorn River, the flow of which is regulated, would generally have the largest impact of any tributary during low flow periods of the Yellowstone. Rosebud Creek has minimal effect. The major contribution of dissolved materials and sediment from the Tongue occurs during the Tongue's high flows. Biological conditions in this part of the Lower Yellowstone, a warm-water fishery, appear to have improved by control of pollution sources in the Billings and Hardin areas. This unit is classified B-D_3 (B-3).

k. Lower Yellowstone River Basin

The Lower Yellowstone River Basin in Montana includes the Yellowstone River and all of its tributaries from Miles City (excluding the Tongue River) to the North Dakota border. With the exception of the Powder and Yellowstone Rivers, most streams in this basin are quite small and many have intermittent flow. With the exception of Baker Lake on Sandstone Creek, there are no large reservoirs in the basin.

The basin drains about 11,650 square miles, an area of rolling hills with gentle to moderate relief. The area is sparsely forested.

Soil groups in the basin have erosion potentials ranging from slight to severe. Salt contents and runoff characteristics also vary. The most erodible soils in the basin are those on the dissected sedimentary plains and the rough, broken uplands. Many of the streams in the basin carry high concentrations of dissolved and suspended minerals and salts from these soils.

Elevations in the basin range from 2,000 up to 5,000 feet. The basin's climate is typical of the semi-arid Northern Great Plains region with dry, cold winters and warm summers, variable rainfall and low humidity.

June is usually the wettest month and average annual precipitation ranges between 12 and 14 inches. Both abnormally wet or dry years can occur. Miles City has seen extremes of 6.1 to 22.8 inches of annual precipitation.

Sixty-two percent of the basin is rangeland and used for livestock grazing. Cropland takes up only 15 percent of the basin and only 12 percent of that is irrigated.

The basin has some extensive oil fields between Glendive and Baker and at least one small strip mine at Savage.

Population of the basin in 1970 was 58,712. Population projected for 1980 is only 37,000. Miles City (population 9,073 in 1970), Glendive (6,505), and Sidney (4,543) are the largest cities in the basin.

The primary water use in the Lower Yellowstone Basin is for irrigation to produce hay. At least three-fourths of a million acre-feet a year are diverted with about 185,000 acre-feet consumed or depleted. Municipal water use is 3,250 acre-feet annually. Industry consumes from 224 to 1,120 acre-feet. Water use in the basin will continue to grow as coal development grows.

The Lower Yellowstone Basin has seven hydrologic units:

Lower Yellowstone - Sunday Creek (10100001). The Yellowstone River and the Sunday Creek drainage to the north are the major streams in this unit. (The upstream portion of this unit was described at the end of the Middle Yellowstone Basin chapter.) Sunday Creek is intermittent, although high flows can be obtained in the creek during periods of snowmelt and rain runoff. Remaining streams in the basin possess small drainage areas and are intermittent. Waters in Sunday Creek are of poorer quality than the Yellowstone's. Specific conductance, dissolved solids and sodium absorption ratios are markedly higher in Sunday Creek. Sunday Creek is a sodium-sulfate type water. The chemical

character of the Yellowstone River is related to flows. The waters are predominantly calcium-bicarbonate-sulfate during the spring high flow, while predominantly calcium-sodium-sulfate during low flows. Sunday Creek is quite distinct in the basin for its high chloride concentrations. As with most streams in the basin, Sunday Creek is a warm-water habitat unsuitable as a trout fishery. The Yellowstone here is classified B-D_3 (B-3) and Sunday Creek is B-D_3 (C-3).

Little Powder (10090208). The Little Powder River originates on the eastern slopes of the Bighorn Mountains in Wyoming. It and all of its tributaries are intermittent. Water quality of the Little Powder is relatively poor with high hardness and specific conductance, dissolved solids and sodium adsorption ratio values. Turbidities are consistently high even during low flows. The river is classified B-D_3 (C-3).

Middle Powder (10090207) and Lower Powder (10090209). The Powder River also originates in Wyoming's Bighorn Mountains and is regulated by three storage reservoirs in Wyoming and by several irrigation diversions. The Middle Powder in Montana encompasses the Powder from the Wyoming border downstream to the confluence with the Little Powder. The Lower Powder unit takes in the rest of the river to the Yellowstone. The Powder River is a perennial stream, but zero flows have been recorded. In general, water quality is poor with high dissolved solids, specific conductance, sediment and sodium adsorption ratio values. The river also has a relatively high concentration of strontium at both high and low flows. The Powder has the potential to degrade the Yellowstone River, particularly at periods of high flows in the Powder. Natural erosion has put so much suspended sediment into the Powder that the river has been called "too thick to drink and to thin to plow." It is a minor, warm-water fishery. It is classified B-D_3 (C-3).

Mizpah Creek (10090210). Another intermittent stream, Mizpah Creek is a tributary of the Lower Powder River and has the same poor water-quality characteristics as those units listed above. It is classified B-D_3 (C-3).

Lower Yellowstone (10100004). This 4,667 square-mile unit contains the Yellowstone River mainstem and its tributaries between the Powder River confluence and the North Dakota border. O'Fallon Creek (a separate unit described below) is the only major tributary of the Lower Yellowstone. There is substantial diversion for irrigation along the Yellowstone in this reach. Other tributaries are insignificant, intermittent, prairie-type streams with consistently poorer quality waters than the Yellowstone mainstem. The only exception is Fox Creek, a relatively high quality water that supports a trout fishery and is classified B-D_2 (B-2). The Yellowstone mainstem here is classified B-D_3 (B-3) and all other tributaries are classified B-D_3 (C-3). By the time the Yellowstone reaches North Dakota, the Montana concentration of dissolved constituents and suspended sediments have reached their peak, thanks to contributions from the tributaries. In this unit, areas of saline seeps add to the degradation. Still, the Yellowstone's water is of higher quality during high flows in the river. This section of the Yellowstone is strictly a warm-water fishery.

O'Fallon Creek (10100005). O'Fallon Creek originates in the rolling foothills southwest of Baker, Montana and flows northward to meet the Yellowstone River. It appears to be perennial, at least near its mouth, but it doesn't have very large flows except during periods of major runoff. Sandstone and Pennel Creeks are the only tributaries of note and they are intermittent. Water in O'Fallon Creek is a poor quality, sodium-sulfate type. Quality is best during high flows and improves downstream from Ismay to Fallon, Montana. The creek's effects on the Yellowstone River are minimal. The creek is a minor warm-water fishery near its mouth. It is classified B-D_3 (C-3).

1. Little Missouri River Basin

The Little Missouri River Basin covers about 3,360 square miles in extreme southeastern Montana. The basin is an area of rolling hills with gentle to moderate relief. There are only four perennial streams in the drainage: Beaver Creek, Little Beaver Creek, Boxelder Creek, and the Little Missouri River. An area of about 11 square miles in the extreme southeast corner of the basin drains into the Belle Fourche River in Wyoming and South Dakota. All of the remaining streams are tributary to the Little Missouri River, which in turn flows into the Missouri River at Lake Sakakawea, North Dakota.

The Little Missouri River Basin has a semi-arid climate characterized by cold dry winters, cool moist springs and warm summers. The average annual precipitation for the area ranges from 11 to 14 inches. Approximately 75 percent of the precipitation falls during the April through September growing season, which permits extensive dryland farming.

The primary source of water for stock and domestic purposes in the Little Missouri River Basin is wells, and over much of the area wells are the only source of potable water. There are an estimated 1,000 to 1,250 wells in the basin and an estimated 300 to 400 springs that have been appropriated for use. The towns of Ekalaka and Wibaux obtain water from wells.

Soils in the basin are used for dryland and irrigated crops and for range. Soils on flood plains, low terraces, fans and foot slopes are used mainly for dryland crops with some areas under irrigation. Soils on uplands are used mainly for range with some gently to moderately sloping soils used for dryland crops.

The main land use in the Little Missouri River Basin is for livestock grazing. Of the more than two million acres of land in the basin, approximately 80 percent is classified as grazing land. About 182,000 acres of land in the basin are under cultivation and about 42,000 acres of these are irrigated. Other land uses include roads, railroads, oil and gas production, bentonite mining and urban development. Although the northern half of the basin has extensive reserves of lignite coal in the Fort Union Formation, no commercial coal development is presently underway.

The predominant water use in the basin is for irrigation of forage for livestock. Much of this irrigation has been developed privately by individuals and small groups through construction of diversions, small dams and reservoirs, and extensive water spreading systems. In the same manner, they have developed a large number of stock watering facilities, which is another significant water use. The most substantial industrial use of water is in water flooding for secondary recovery of oil. Injection water for secondary recovery originates from process water separated from oil or from water wells. Municipal and rural domestic water use is reflective of the low population density and is largely unquantified except for the communities of Alzada, Ekalaka and Wibaux.

Total 1970 population in the basin was estimated to be 3,421. This population is largely rural and agricultural; in 1970, the four major communities in the basin had a combined population of 1,370. The population trend in the basin has been downward since 1930.

Of the five U.S.G.S. hydrologic units in the basin, only three--Upper Little Missouri (10110201), Boxelder (10110202), and Beaver (10110204)--have perennial streams. Nevertheless, water quality throughout the Little Missouri River Basin is uniformly poor to fair. The water is a sodium-sulfate type with concentrations of both sulfate and total dissolved solids usually in excess of drinking water criteria. Surface waters in the basin are presently classified B-D3, but their general unsuitability for drinking purposes has prompted the Water Quality Bureau to reclassify them C-3 in the proposed revisions to the Water Quality Standards.

m. Kootenai River Basin

The Kootenai River Basin is a well-watered region of steep, heavily timbered mountains and narrow valleys. The area is sparsely inhabited and contains few industries and communities. Timber harvest, mining and tourism are the primary commercial activities. A major hydroelectric installation--Libby Dam--has turned a good share of the once free-flowing Kootenai River into slack water. Other hydroelectric developments on the Kootenai are being planned, and a major copper mining and milling facility is under construction near Libby.

Precipitation in the basin is mostly 12 to 24 inches per year and up to 48 inches per year or greater in the mountains. The frost-free growing season ranges from 80 to 120 days and the mean annual temperature is about 42° F. Elevations in the basin range from nearly 9,000 feet in the Cabinet Mountains to about 1,800 feet where the Kootenai River leaves the state near Troy, the lowest point in Montana.

Over ninety percent of the 2.4 million acres of land in the Kootenai River Basin are national, state, industrial and small private forest lands. Soils used primarily for the production of forest products present a moderate to severe erosion hazard. Agriculture is a relatively minor pursuit in the basin. Commercially attractive copper and vermiculite deposits have prompted exploration and mining. Roadless and wilderness areas attract increasing numbers of visitors each year.

The Kootenai River Basin includes some of the purest waters in America; concentrations of dissolved chemicals are among the lowest in Montana. Streams are significantly less productive and potentially more sensitive to acid mine drainage and heavy metals pollution than streams elsewhere in Montana.

Portions of five hydrologic units comprise the Kootenai River Basin in Montana: Upper Kootenai, Lower Kootenai, Yaak, Moyie, and Fisher. The Moyie River unit (17010105) and the Lower Kootenai unit (17010104) are insignificant in areal extent in Montana and, for planning and reporting purposes, shall be included with the Yaak and Upper Kootenai units, respectively.

Upper Kootenai River (17010101).

Waters of the Kootenai drainage have soft to medium hard, calcium/magnesium/bicarbonate waters. Low alkalinities help to explain why these waters are relatively infertile and their low buffering capacity makes them among the most sensitive in the state to heavy metals pollution. The principal surface water quality problems in the basin are nutrient enrichment to Lake Koocanusa from Canadian sources and gas super saturation in the Kootenai River below Libby Dam. Logging and mining activities have affected water quality in various tributaries. Recent developments bearing close scrutiny are proposed additional hydropower units on the Kootenai River and copper exploration, mining and milling activities in the Lake Creek drainage. All waters in the drainage are classified B-D_1 (B-1) or better except a portion of Rainy Creek, which is classified C-D_1 (C-1).

Fisher River (17010102).

Like the Yaak, the Fisher River drainage is also relatively undeveloped. Pollution has been from diffuse sources, namely sediment accelerated by logging, roading, stream alterations, and poor land use practices. However, all waters in the drainage are classified B-D_1 (B-1).

Yaak River (17010103).

The Yaak River drainage is relatively undeveloped except for a few scattered homesites. There are no known domestic or industrial discharges. Surface water quality is good to excellent, except for natural turbidity during spring runoff. All waters in the drainage are classified B-D_1 (B-1).

n. Upper Clark Fork River Basin

The Upper Clark Fork River Basin is an area of moderately-timbered and highly mineralized mountain ranges separated by broad agricultural valleys. This basin is to the Columbia River system as the adjacent Upper Missouri Tributaries basin is to the Missouri River: they are both headwaters to major continental river systems. Lying on either side of the Continental Divide, they have many features in common.

Elevations in the drainage range from over 10,000 feet in the Anaconda Range to slightly over 3,000 feet near Missoula. Total precipitation generally increases with elevation, with more snowfall in the mountains. Valley precipitation ranges from 8 to 20 inches annually, most of it falling in late spring and early summer.

Soils of the Upper Clark Fork River Basin vary widely in their physical and chemical properties due to the complicated geological history of the area. Soils used for timber, range, wildlife and water production range from very shallow, high mountain soils with rock outcrops to light-colored, deep, loamy soils with gravelly subsoil on the lower slopes. Valley soils used for irrigated pasture, range and hay production are generally deep, dark-colored, loamy soils with a gravelly substratum.

The basin comprises an area of 6,115 square miles or nearly four million acres of land above Missoula. Forest lands cover 2.3 million acres, pasture and range 880,000 acres, urban and built-up areas 54,000 acres, and small water areas 9,700 acres. Irrigated cropland covers 150,000 acres of the basin and dry cropland exceeds 23,000 acres. Irrigated agriculture accounts for the largest use of water in the basin; total diversion requirements for irrigation approach 500,000 acre feet per year with a net depletion of nearly one-half that amount.

Mean annual instantaneous discharge out of the basin at a point just above Missoula is about 3,000 cfs. Over half of this average annual flow (1,658 cfs) is contributed by the Blackfoot River at Bonner. There are two

hydroelectric plants in the basin, Flint Creek at Georgetown Lake and Milltown near Bonner on the Clark Fork. Principal cities in the basin are Butte, Anaconda and Deer Lodge. The major industry in the basin is mining and minerals processing.

Water quality varies considerably within the basin. Silver Bow Creek below Butte has some of the worst water quality in the state, while Rock Creek near Missoula is considered by many as a "blue ribbon" trout fishery. Pristine, nearly sterile, high mountain lakes dot some of the higher mountain ranges in the basin, while eutrophic Georgetown Lake near Anaconda is probably the most productive fishery in Montana.

The Upper Clark Fork River water quality management basin consists of three hydrologic units: Upper Clark Fork, Flint-Rock, and the Blackfoot.

Upper Clark Fork River (17010201).

The Upper Clark Fork River has a long history of water pollution associated with the Anaconda Company facilities at Butte and Anaconda. However, much progress has been made in recent years to the point where the Upper Clark Fork River now supports a viable trout fishery. From its headwaters at the confluence of Silver Bow Creek and Warm Springs Creek, the Clark Fork River is classified C-D_2 (C-2) to the mouth of Cottonwood Creek near Deer Lodge, largely because of high sulfate concentrations. From here to the mouth of the Little Blackfoot River the Clark Fork is classified C-D_1(C-1). Silver Bow Creek below Butte continues to be degraded by municipal and industrial discharges and by its close proximity to old, metals-laden tailings, which comprise the channel in certain reaches. This stream retains an E-F (E) classification in the revised (1980) water quality standards. All remaining streams in the drainage are classified B-D_1 (B-1) or better. Nutrients from municipal discharges and perhaps from the Phosphoria Formation near Garrison have resulted in blooms of Cladophora from below Deer Lodge to the mouth of Rock Creek. Coupled with summer low flows and high water temperatures, these blooms have periodically resulted in dissolved oxygen levels that are marginally low for the propagation of salmonids.

Flint-Rock Creeks (17010202).

Rock Ceek provides an environment for spring and fall spawing of salmonid species and is one of Montana's premier trout streams. There are no significant water quality problems on Rock Creek and it conforms well to its B-D_1 (B-1) classification. Georgetown Lake near the head of Flint Creek is one of the state's most popular and productive fisheries. It also suffers from symptoms of eutrophication, including critically low winter dissolved oxygen levels. Flint Creek itself is generally in pretty good shape except for some historical mine drainage and sediment problems in the Philipsburg area and dewatering for irrigated agriculture. All waters in the Flint Creek drainage are classified B-D_1 (B-1) or better.

Blackfoot River (17010203).

Water quality is generally good in the Blackfoot River and its tributaries. However, some of the extreme headwaters suffer from acid mine drainage and some

tributaries lower in the drainage have been impacted by logging practices. The Blackfoot's major tributary---the Clearwater River--also has good quality water. Placid Lake, an 11,000 acre lake in the Clearwater drainage, has eutrophication problems and appreciably poorer quality than other lakes in the Clearwater chain. All waters in the Blackfoot drainage are classified B-D_1 (B-1).

o. Lower Clark Fork River Basin

The Lower Clark Fork River Basin, along the western border of Montana, comprises an area of 8,900 square miles or over five and one-half million acres. This area includes 1,900 square miles of the Flathead River basin below Flathead Lake, 2,800 square miles of the Bitterroot River drainage, and all of the Clark Fork drainage below the Blackfoot River. About 60 percent of the basin is in federal ownership, mostly national forest land. Cropland covers about 400,000 acres, two-thirds of which is irrigated. Urban and builtup areas cover approximately 68,000 acres.

Climate of the Lower Clark Fork River Basin is variable, depending on elevation. Annual precipitation ranges from less than 10 inches southwest of Flathead Lake to over 80 inches in the higher mountains. At lower elevations, springs are wet and cool, summers warm and dry with occasional thunder showers, and winters cold and dry although cloudy. Elevations in the basin range from over 10,000 feet in the Bitterroot Range to about 2,000 feet where the Clark Fork River enters Idaho.

Soils of the basin show great variation in their chemical and physical properties due to effects of climate, topography, and glaciation. Extensive areas in the northwest part of the basin have been covered with volcanic ash. Soils developed over this ash are susceptible to erosion, particularly where they have been disturbed for timber production. Very slowly permeable claypan soils have developed in varved lakebed sediments in the Little Bitterroot and the Flathead River areas. These soils are highly susceptible to erosion from surface water runoff. Light colored silty or clayey soils are found along the Flathead River breaks. They present a severe erosion hazard.

The 1970 population for the Lower Clark Fork planning area was about 90,000, much of it, along with the basin's major industries, concentrated in the Missoula area. Although it accounts for only about 15 percent of the land area, agriculture is by far the largest water user in the basin. Annual diversion requirements for irrigation approach 1.6 million acre feet of water with a net depletion of 760,000 acre feet per year. Municipal use is about 34,000 acre feet per year and industrial use is about 22,000 acre feet per year.

The average annual flow of the Clark Fork River at Missoula is about 3.9 million acre feet, increasing to about 16 million acre feet near the Idaho border. The Flathead River, with an average yearly flow in excess of 8.5 million acre feet, accounts for the major portion of this increase. Other significant rivers in the basin are the Bitterroot, the St. Regis, and the Thompson.

Water quality in the basin is variable. Generally, smaller rivers and streams flowing through concentrated agricultural areas are most

degraded, with temperatures, suspended solids concentrations and other parameters indicating the effects of irrigation diversions and return flows. Municipal and industrial effects are present but subdued. Streams flowing through remote areas have excellent water quality tempered only by the effects of seasonal runoff.

The following is a brief water quality overview of the major stream segments within the Lower Clark Fork basin:

Middle Clark Fork River (17010204).

Water quality entering the basin near Missoula still retains some residual effects of municipal and industrial waste discharges far upstream in the Butte/Anaconda/Deer Lodge area. Because of the large volume of flow in the receiving water and recent improvements in wastewater treatment facilities for the City of Missoula and the Hoerner-Waldorf paper mill, these discharges do not have a documented effect on water quality and water use in the Clark Fork River below Missoula. The Hoerner-Waldorf plant has imparted organic color to the water and possibly has affected levels of phenols and algal nutrients in the Clark Fork River. Instream levels of toxic ammonia may be a problem below the Missoula sewage treatment plant but this will need to be verified through a rigorous and intensive sampling program. All waters in this hydrologic unit are classified B-D_1 (B-1) or better.

Bitterroot River (17010205).

Flows in the middle portions of the Bitterroot River are greatly reduced by irrigation diversion during summer months. Allthough irrigation return flows help maintain instream flows toward the mouth of the river, they also return additional sediment and nutrients to the river. Water quality data from the mouth of the Bitterroot do not indicate any violations of water quality standards, although nitrates and coliform levels indicate some degradation. It is also suspected that there are significant late summer increases in temperature and conductivity and decreases in dissolved oxygen at the river's mouth. Dewatering for agricultural use appears to have a more adverse effect on water quality in the Bitterroot River than the combined municipal and industrial discharges. The many tributaries of the river are of generally excellent quality. Natural runoff episodes and activities such as road construction and logging may cause temporary problems in any of the tributaries. All waters in this hydrologic unit are classified B-D_1 (B-1).

Lower Flathead River (17010212).

This hydrologic unit includes all waters drained by the Flathead River from the lower end of Flathead Lake at Polson to the confluence of the Flathead and Clark Fork rivers. Water quality of the Flathead River is excellent, due in part to its large size and dilution capacity and in part to the upstream presence of Flathead Lake, which serves as a settling basin. Only during spring peak flow periods is water quality reduced due to natural causes. A number of Flathead River tributaries have only fair to poor water quality. Causes include irrigation dewatering and return flows,

livestock trampling of streambanks, very fragile soils, and livestock overgrazing. Portions of Crow and Mission creeks and the Little Bitterroot River suffer from one or more of these problems and have been classified $B\text{-}D_2$ (B-2) accordingly. Hot Springs Creek below the Hot Springs water supply intake is classified E-F (E) largely because of severe and chronic dewatering. In addition, fish kills have been documented on the Jocko River due to pesticide misuse. All of these degraded streams are relatively small, low-gradient streams flowing through areas of intensive agricultural use. The remaining streams in the hydrologic unit are classified $B\text{-}D_1$ B-1), or better in the case of certain drinking water supplies.

Lower Clark Fork River (17010213).

Studies indicate that water quality problems in the Clark Fork River, resulting from municipal and industrial discharges far upstream, become stabilized by natural assimilation and dilution in the vicinity of Alberton, Montana. Below Alberton the water quality of the Clark Fork is good to excellent until it leaves Montana. The Clark Fork River loses its free-flowing character above Thompson Falls, where it begins its traverse of three artificial reservoirs before entering Idaho. Tributaries to the Clark Fork River below Alberton (except those in the Flathead drainage discussed above) are of uniformly excellent water quality. In most cases they originate and flow through remote, undeveloped areas. Occasional localized problems may be related to cattle access to streams or to faulty septic tanks. One continuous and one occasional municipal discharge of treated sewage exists in the Clark Fork segment below Alberton. No measurable water quality problems have been attributed to these discharges. All waters in this hydrologic unit are classified $B\text{-}D_1$ (B-1) or better.

P. Flathead River Basin

The Flathead River Basin drains much of the northern Rocky Mountain region in northwestern Montana. It extends south from the Canadian border, west from the Continental Divide, north from the lower end of Flathead Lake, and east from the Whitefish and Salish Mountains. The region is largely mountainous and forested, with agriculture restricted to the mostly narrow valley bottoms. The one notable exception is the broad north-south trough that contains Flathead Lake and the agricultural/commercial/recreational heart of the basin: The Flathead Valley. Most of the basin is sparsely inhabited except for the area centering around the Flathead Valley city of Kalispell, which is one of the fastest growing regions of Montana.

Elevations in the drainage range from over 10,000 feet in Glacier National Park to about 2,900 feet on Flathead Lake. The climate is moist and cool, influenced both by Pacific weather systems from the west and by the stabilizing mass of 185 square mile Flathead Lake. Annual precipitation varies from about 50 inches in the mountains to as little as 10 inches in the lower Flathead Valley.

In general, the Flathead Valley was formed by down faulting in the late Paleocene era and reshaped during the Pleistocene, when glaciers carved the upper drainages and huge glacial lakes inundated the valley floor. Much of the valley is underlain by glacial till and outwash materials covered by a thin mantle of glacial-lacustrine silt and sand.

As a headwater drainage of the Clark Fork-Columbia River system, the Flathead has some of the purest waters in America; concentrations of suspended sediment and dissolved chemicals are generally among the lowest in Montana streams. With few exceptions, waters in the basin are suitable for all beneficial uses following minimal treatment. Water quality problems are usually associated with surface disturbances, concentrations of livestock or people, and with large hydroelectric dams. Forestry, mining and agriculture are the primary land-disturbing activities. The following is a brief overview of the major stream segments within the Flathead drainage:

North Fork Flathead River (17010206).

The North Fork begins in Canada and flows south through a narrow forested valley along the west edge of Glacier National Park. It is a highly attractive, high gradient, rocky-bottomed trout stream with an average discharge of about 3,000 cfs. Water quality is very good, but problems could arise from proposed Canadian coal mining activities and from logging and oil exploration activities south of the border. As do all of the streams in the Flathead Basin, the North Fork contributes sediment and algal nutrients to Flathead Lake, although concentrations are generally less than in other streams tirbutary to the Lake. The North Fork and tributaries are classified B-D_1 in the existing Montana Water Quality Standards (B-1 in the proposed revised standards).

Middle Fork Flathead River (17010207).

The Middle Fork originates in Montana along the Continental Divide in the roadless area south of Glacier National Park. Thence it flows northwesterly through a forested canyon along the southern edge of Glacier Park to its confluence with the North Fork near West Glacier, Montana. It is very similar to the North Fork in terms of gradient, bottom materials, discharge, and water quality. It carries less phosphorus than the North Fork but its sediment loads are considerable, particularly during runoff. The drainage is subject to some of the same potential water quality impacts as the North Fork, including energy exploration and development and, to a lesser extent, logging. The Middle Fork and its tributaries are classified as B-D_1 (B-1) or better.

South Fork Flathead River (17010209).

The South Fork is the longest and largest of the three principal tributaries of the Flathead River system in Montana. It is primarily a roadless stream, draining much of the Bob Marshall Wilderness Area. Just

above its confluence with the combined North-Middle forks near Columbia Falls the South Fork is impounded by Hungry Horse Dam. Although Hungry Horse Reservoir removes much of the silt that would otherwise find its way to Flathead Lake, reservoir releases have created thermal and flow fluctuation problems downstream. The South Fork and its tributaries are classified as B-D_1 (B-1).

Stillwater River (17010210).

The Stillwater and Whitefish rivers are the principal stream segments within this hydrologic unit at the northern end of the Flathead Valley. Both are low gradient rivers through agricultural areas in their lower reaches. These lower segments are classified B-D_2 (B-2) largely because of natural problems aggravated by agricultural nutrient and sediment additions and irrigation water withdrawals. Additionally, the Whitefish River is affected by the City of Whitefish wastewater discharge. Other streams within this hydrologic unit, including the Stillwater River's major tributary--Logan Creek, are high quality waters classifiied B-D_1 (B-1) or better.

Swan River (17010211).

The Swan River drains the forested valley between the Swan and Mission mountain ranges east and south of Flathead Lake. Water quality is very good in spite of moderate to heavy logging and subdivision activity. Waters throughout the drainage are classified B-D_1 (B-1), except for Swan Lake, which is classified as A-1 and suitable for drinking after simple disinfection and removal of naturally present impurities.

Flathead Lake (17010208).

The principal waters in this hydrologic unit are the Flathead River from the confluence of the North-Middle forks to Flathead Lake, Ashley Creek, and Flathead Lake itself. In the reach of the Flathead River above Flathead Lake, cold water releases from Hungry Horse Reservoir have the greatest hydrologic and water quality effects. This reach also receives considerable nutrient loadings from agricultural sources, including those along the Stillwater and Whitefish rivers, but because of substantial dilution it retains a classification of B-D_1 (B-1). Ashley Creek is a sluggish, low-gradient stream in an agricultural sector of the Flathead Valley near Kalispell. Naturally marginal water quality is further compounded by the discharge from the Kalispell sewage treatment plant. Lower Ashley Creek is currently classified E-F with a proposal to upgrade this classification to C-2 in the most recent revisions of the Montana Water Quality Standards. Lowermost in the Flathead Basin is Flathead Lake, a very large oligotrophic lake and one of the largest, if not the largest natural freshwater lake in the U.S., excluding the Great Lakes. In recent years, nutrient additions have triggered nuisance algal growths in certain isolated portions of the lake. Sufficient phosphorus is entering the lake via the Flathead River to cause serious algal problems, but much of this phosphorus is being tied up with sediments that settle to the bottom following spring runoff; the north half of the lake seasonally becomes quite turbid in years of heavy runoff. Flathead Lake, as well as Lake Mary Ronan, is classified A-1. The remaining waters in this hydrologic unit are classified B-D_1 (B-1) except for those noted above.

2. Fisheries Inventory

Information on water pollution presented in this chapter is derived from data entered to date into the Montana Interagency Stream Fishery Data Base, which is maintained by the Montana Department of Fish, Wildlife and Parks. The data represent inventories of stream reaches by the Montana Department of Fish, Wildlife and Parks; the U.S. Forest Service; and to a lesser degree, the U.S. Bureau of Land Management. The portion of the inventory that is of interest here indicates which of various man-related activities are affecting the value of the stream fishery. These activities or categories of activities are explicit or implicit indicators of water quality problems in a particular stream reach, hydrologic unit, or drainage basin. A stream reach is defined as "a length of stream with distinct physical characteristics." Categories are grouped into four areas, namely "man-caused pollution," "watershed abuse," "water removal and fluctuation," and "management needs and recommendations."

Inventory data were recalled from the data base and compiled by means of computer programs. In each category, data were recalled for two parameters--number of stream reaches affected and the total kilometers of those affected reaches. Not reported is the degree of effect or the length of reach affected.

In each category, data were aggregated at three levels of detail. First, an alphabetical listing of each affected reach was prepared, including stream name, reach boundaries, length, and nature of pollutant(s). A copy of this lengthy computer listing is on file at the Water Quality Bureau, Montana Department of Health and Environmental Sciences.

Next, the data were aggregated by U.S.G.S. hydrologic unit (Appendix B). These aggregations are presented in Tables 8 through 11. Then, the data were further aggregated according to Montana Department of Fish, Wildlife and Parks drainage basins. These specialized basins, and their identifying codes, are given below:

01 = Beaverhead
02 = Big Hole
03 = Bitterroot
04 = Blackfoot
05 = Clark Fork (below Bitterroot R.)
06 = Clark Fork (above Bitterroot R.)
07 = Flathead (below South Fork)
08 = Flathead (above & including South Fork)
09 = Gallatin
10 = Jefferson
11 = Kootenai
12 = Little Missouri
13 = Madison
14 = Marias
15 = Milk
16 = Missouri (below Marias R.)
17 = Missouri (above Marias R.)
18 = Musselshell
19 = St. Mary
20 = Sun
21 = Yellowstone (below Bighorn R.)
22 = Yellowstone (above and including Bighorn R.)

Aggregations by Fish, Wildlife and Parks drainage basins are presented in Tables 12 through 15. Finally, at the end of each of these tables, data for each category are further aggregated for the state as a whole.

It should be noted that not all of the inventoried reaches were surveyed for these water quality related categories. The original computer data file contained records on 2858 stream reaches. Of these, 1374 had no information on water quality related problems in the categories considered here. These reaches either had no problems or were not surveyed in these categories. Further, 108 stream reaches were eliminated because of possible overlap of reaches for which data were entered by two agencies. The remaining 1376 reaches had indications of problems in one or more of the categories.

a. "Man-caused Pollution" (Tables 8 and 12)

Notable in this area is the significant number of stream reaches (201) in which the fishery has been judged to be affected by excess silt. Forty-two percent of these reaches (84) are located in the Missouri River drainage above the mouth of the Marias River. Other categories judged to be affecting large numbers of stream reaches are irrigation-related pollutants (166), domestic livestock (164), mining (70), and domestic sewage (64).

b. "Watershed Abuse" (Tables 9 and 13)

Of the seven categories in this area, only three accounted for most of the stream reaches judged to be affected by watershed abuse. These three categories were livestock (241), logging (235), and road construction (146).

c. "Water Removal and Fluctuation" (Tables 10 and 14)

Water removals and fluctuations by agriculture (irrigation) were judged to affect fisheries in the great majority of the reaches affected by categories in this area. Removals and fluctuations for other purposes were of relatively minor significance statewide. More than a third of the reaches affected by agricultural water removals and fluctuations are located in the Missouri River drainage above the mouth of the Marias River.

d. "Management Needs and Recommendations" (Tables 11 and 15)

Only the categories in this area that relate to water pollution are tallied and reported. The largest category, both in terms of number of reaches and total kilometers of streams, is the category of stream reaches needing to be surveyed to determine management needs. Categories of management needs including a significant number of stream reaches are watershed restoration (179), cover improvement (160), and bank stabilization (140). Recommendations for pollution abatement were made for 61 stream reaches totalling 1380 kilometers.

Table 8

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
MAN-CAUSED POLLUTION CATEGORIES

USGS UNIT	MINING RELATED		THERMAL EFFLUENT		COMM. CHEMICAL		COMM. ORGANIC		EXCESS SILT		IRR/RUNOFF RELATED		DOM. SEWAGE		DOM. STOCK		WEED/PEST CHEMICAL	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10020000																		
10020001									134	9	39	1			34	8		
10020002	47	2					4	1	91	5	18	2	53	4	4	1		
10020003									64	4	54	1	3	2	35	4		
10020004	49	5			5	2			26	2	25	2	13	4	24	10		
10020005	134	5							138	4	15	1	15	1			15	1
10020006	165	11							95	4	72	2			2	1		
10020007	12	2							58	5	27	1	6	1	20	6		
10020008									136	12	64	6	57	11	7	5		
10030101	66	3			34	1			164	10	85	5			1	3	23	2
10030102					4	1			291	8	151	6	18	2				
10030103	73	4	184	4					338	15	145	11	20	8	7	2		
10030104									64	3	254	20			20	2	44	3
10030105	146	7							75	3	13	1	26	1				
10030201	2	1							7	1	104	15			11	1		
10030202																		
10030203																		
10030205									22	1	7	3			53	2		
10040101									135	1								
10040102									15	1					13	1		
10040103	13	1							186	8	48	1	31	2				

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
MAN-CAUSED POLLUTION CATEGORIES

USGS UNIT	MINING RELATED		THERMAL EFFLUENT		COMM. CHEMICAL		COMM. ORGANIC		EXCESS SILT		IRR/RUNOFF RELATED		DOM. SEWAGE		DOM. STOCK		WEED/PEST CHEMICAL	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10040104															48	1		
10040201											32	2						
10040202																		
10040203									17	2	96	1						
10040204																		
10040205																		
10050002																		
10050004											376	4	127	2	127	2		
10050005																		
10050009	32	1																
10050010									41	3	14	1			41	3		
10050011									50	1					50	1		
10050012											165	2						
10050014									34	1	34	1			34	1		
10050015															120	1		
10060001															16	1		
10060003																		
10060006									155	2			155	2	43	1	43	1
10070001	12	2											8	1				
10070002									19	2			1	1	38	11		
10070003									66	4	8	2			51	11		

Table 8

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
MAN-CAUSED POLLUTION CATEGORIES

USGS UNIT	MINING RELATED		THERMAL EFFLUENT		COMM. CHEMICAL		COMM. ORGANIC		EXCESS SILT		IRR/RUNOFF RELATED		DOM. SEWAGE		DOM. STOCK		WEED/PEST CHEMICAL	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10070004											35	1						
10070005	39	3							35	3	98	10	7	3	7	3		
10070006	36	2							388	19	378	22	24	2	48	8	7	3
10070007													17	1				
10070008											12	1						
10080010																		
10080014											11	1			11	1		
10080016									74	1					74	1		
10090101																		
10090102																		
10090207																		
10090208																		
10100001																		
10100004																		
10110201															2	2		
17010101	31	2	76	2					72	4	72	5	100	3	54	5		
17010102									148	5					38	2		
17010103																		
17010201	7	1			61	1	80	2	216	5	231	10	199	5	241	11	62	2
17010202	17	3							102	5			42	1	169	14		
17010203	5	1							362	15	188	4			285	9	135	3
17010204	136	11			100	1	100	1	276	9	243	14	168	2	151	13	168	2

Table 8

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
MAN-CAUSED POLLUTION CATEGORIES

USGS UNIT	MINING RELATED		THERMAL EFFLUENT		COMM. CHEMICAL		COMM. ORGANIC		EXCESS SILT		IRR/RUNOFF RELATED		DOM. SEWAGE		DOM. STOCK		WEED/PEST CHEMICAL	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
17010205	57	2	31	1					249	9	177	6			55	6	144	4
17010206									88	5								
17010207									18	1								
17010208			66	2					7	1			35	1	42	2		
17010209			8	1											8	1		
17010210									46	4			31	3	8	1		
17010211																		
17010212			11	1					21	2								
17010213	13	1							40	2	13	1	13	1	91	6		
STATE TOT	1092	70	376	11	204	6	184	4	4563	201	3304	166	1169	64	2083	164	641	21

Table 9

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
WATERSHED ABUSE CATEGORIES

USGS UNIT	ROAD CONST		LOGGING		MINING		STOCK		GAME		PEOPLE		OTHER	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10020000														
10020001							239	22						
10020002					47	2	115	4			39	1	60	2
10020003	114	4			3	1	141	9						
10020004	9	4	24	5	23	5	54	17						
10020005	26	2			128	4	123	3						
10020006	52	3	9	2	132	9	3	1						
10020007	11	2	20	4	6	1	89	11						
10020008	17	2	31	7			104	10			3	2		
10030101	43	1	5	1	17	3	145	9						
10030102	16	1	19	2			320	14						
10030103	78	2	279	13	110	5	616	30						
10030104	6	1			29	1	31	3					98	5
10030105	128	5	36	3	105	5	130	7						
10030201	6	2												
10030202														
10030203														
10030205			2	1			37	3						
10040101							135	1						
10040102							13	1						
10040103	21	1	52	3			164	8						

Table 9

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
WATERSHED ABUSE CATEGORIES

USGS UNIT	ROAD CONST		LOGGING		MINING		STOCK		GAME		PEOPLE		OTHER	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10040104														
10040201			19	3			142	4						
10040202														
10040203			24	3			17	2						
10040204														
10040205							119	1						
10050002														
10050004														
10050005														
10050009														
10050010							30	2						
10050011							50	1						
10050012														
10050014							34	1						
10050015														
10060001														
10060003														
10060006														
10070001			5	1	4	1								
10070002			27	7			28	3						
10070003			58	9			45	4						
10070004							35	1						

Table 9

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
WATERSHED ABUSE CATEGORIES

USGS UNIT	ROAD CONST		LOGGING		MINING		STOCK		GAME		PEOPLE		OTHER	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10070005	43	3			50	2	21	3						
10070006	9	4	11	3	32	2	90	6			1	1	1	1
10070007														
10070008														
10080010														
10080014														
10080016														
10090101														
10090102														
10090207														
10090208														
10100001														
10100004														
10110201														
17010101	204	15	300	24	35	2	134	8						
17010102	46	3	97	4	8	1	103	5						
17010103														
17010201	130	5	209	12	6	2	133	6			8	1		
17010202	63	4	64	5	19	3	1	1						
17010203	166	11	438	20	121	3	204	4						
17010204	422	25	479	35	72	7	109	8					6	1
17010205	94	12	348	22	92	3	225	11						

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
WATERSHED ABUSE CATEGORIES

USGS UNIT	ROAD CONST		LOGGING		MINING		STOCK		GAME		PEOPLE		OTHER	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
17010206	91	5	220	12										
17010207	165	4	147	3										
17010208	80	3	80	3			21	1						
17010209	120	7	150	10										
17010210	56	3	56	3			71	4						
17010211	88	2	88	2			80	1						
17010212							45	3						
17010213	208	10	247	13	30	1	154	8			9	1		
STATE TOT	2512	146	3544	235	1069	63	4350	241			60	6	165	9

Table 10

NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
WATER REMOVAL AND FLUCTUATION CATEGORIES

USGS UNIT	AGRIC.		POWER		INDUSTRY		MUNICIPAL		OTHER	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10020000										
10020001	154	7								
10020002	259	11								
10020003	141	8								
10020004	283	9					3	1		
10020005	262	15							18	1
10020006	82	3								
10020007	64	4	84	3						
10020008	112	11					19	2		
10030101	168	12	46	3						
10030102	217	4	194	5						
10030103	288	16					6	1		
10030104	292	12					13	1		
10030105	43	2					5	1		
10030201	129	6								
10030202	9	1								
10030203	128	1								
10030205	424	10								
10040101	147	2	135	1						
10040102	40	3								
10040103	230	6								

NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
WATER REMOVAL AND FLUCTUATION CATEGORIES

USGS UNIT	AGRIC.		POWER		INDUSTRY		MUNICIPAL		OTHER	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10040104	64	3								
10040201	245	9								
10040202	222	1								
10040203	96	1								
10040204										
10040205	119	1								
10050002										
10050004	439	6								
10050005	6	1								
10050009	28	1								
10050010	14	1								
10050011	50	1								
10050012	197	3								
10050014	34	1								
10050015										
10060001	50	1								
10060003			29	1						
10060006	155	2								
10070001	8	1								
10070002	248	21							1	
10070003	63	5								
10070004										

Table 10

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
WATER REMOVAL AND FLUCTUATION CATEGORIES

USGS UNIT	AGRIC.		POWER		INDUSTRY		MUNICIPAL		OTHER	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10070005	124	10	17	1						
10070006	297	17					6	3	1	1
10070007										
10070008	12	1								
10080010										
10080014	22	2								
10080016										
10090101	40	2								
10090102	140	2								
10090207	350	1								
10090208	107	1								
10100001	141	1								
10100004	230	3								
10110201										
17010101	160	11	76	2	21	1	33	2		
17010102	86	3								
17010103										
17010201	156	11			46	1				
17010202	154	12			17	1				
17010203	245	8					5	1	5	1
17010204	120	9			2	1	5	1	12	2
17010205	357	16								

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
WATER REMOVAL AND FLUCTUATION CATEGORIES

USGS UNIT	AGRIC. KM	AGRIC. NO.	POWER KM	POWER NO.	INDUSTRY KM	INDUSTRY NO.	MUNICIPAL KM	MUNICIPAL NO.	OTHER KM	OTHER NO.
17010206										
17010207										
17010208	7	1	66	2						
17010209										
17010210	92	5								
17010211			23	1						
17010212	35	2	6	1					6	1
17010213	46	3					13	1		
STATE TOT	8431	323	676	20	86	4	108	14	42	7

Table 11

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
MANAGEMENT NEEDS AND RECOMMENDATIONS CATEGORIES

USGS UNIT	NEED SURVEY		POLL. ABATEMENT		RED. FLOW FLUCT.		IMPROVE IRRIG.		IMPROVE COVER		STABILIZE BANK		BANK FENCING		RESTORE WATERSHED	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10020000																
10020001	303	19			12	3	8	1	58	3	20	4	81	3	51	2
10020002	130	7	64	3	66	3	140	5								
10020003	46	6					54	1	130	7	22	5	115	4	134	7
10020004	690	47	27	6	7	2			35	13	22	10				
10020005	229	14	138	4	123	3	123	3			15	1				
10020006	6	1	136	7			72	2	49	1	38	2			15	1
10020007	287	22			3	1			9	2	48	6			8	1
10020008	173	20	61	4					70	4	37	6	20	1	68	4
10030101	378	26	34	1	80	4			196	8	185	8	99	4	162	8
10030102	14	2	14	1	4	1			7	1	107	2	7	1	153	5
10030103	73	7					80	2	124	3	139	4	39	2	546	25
10030104					277	14	271	13	41	4	37	4			111	6
10030105			111	6					54	2	75	3			40	2
10030201																
10030202																
10030203																
10030205					86	3	86	3	59	6	12	2			39	4
10040101																
10040102																
10040103	48	1	10	1	75	2	27	1	210	12	231	10	4	1	31	2

NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
MANAGEMENT NEEDS AND RECOMMENDATIONS CATEGORIES

USGS UNIT	NEED SURVEY		POLL. ABATEMENT		RED. FLOW FLUCT.		IMPROVE IRRIG.		IMPROVE COVER		STABILIZE BANK		BANK FENCING		RESTORE WATERSHED	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10040104	48	1											2	1		
10040201					181	6	30	3	6	1	153	4			123	1
10040202					222	1										
10040203	96	1							18	2	11	1			6	1
10040204	113	1														
10040205	119	1														
10050002	43	1														
10050004							376	4								
10050005																
10050009																
10050010									41	3	41	3	30	2	41	3
10050011									50	1	50	1	50	1	50	1
10050012																
10050014					34	1	34	1	34	1	34	1	34	1	34	1
10050015																
10060001																
10060003					29	1										
10060006	43	1														
10070001	67	6	8	1												
10070002	327	34							85	9	66	9	2	1	22	2
10070003	229	29							27	3	48	3			90	5

NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYOROLOGIC UNIT
MANAGEMENT NEEDS AND RECOMMENDATIONS CATEGORIES

USGS UNIT	NEED SURVEY		POLL. ABATEMENT		RED. FLOW FLUCT.		IMPROVE IRRIG.		IMPROVE COVER		STABILIZE BANK		BANK FENCING		RESTORE WATERSHED	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
10070004	170	4	35	1			35	1								
10070005	217	17	73	4			31	5	56	3	16	1	5	2	56	4
10070006	65	8	7	2					7	2	7	2	20	2	7	3
10070007	107	2	17	1												
10070008																
10080010	5	1														
10080014	11	1														
10080016	74	1							74	1	74	1				
10090101																
10090102	119	1														
10090207																
10090208																
10100001	235	2					141	1								
10100004	224	3					214	2								
10110201																
17010101	200	20	36	2	64	2	43	3	39	21	26	4	37	3	282	20
17010102	27	2	59	2					39	2	72	2	20	1	149	5
17010103	218	14														
17010201	151	8	118	2	56	2	137	4	52	4	60	5			212	5
17010202	63	7	42	1			59	2			1	1			18	1
17010203	207	22	121	3			79	3	271	7	255	7			391	17
17010204	31	6	211	6			100	1	239	19	178	17			310	13

Table 11

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY USGS HYDROLOGIC UNIT
MANAGEMENT NEEDS AND RECOMMENDATIONS CATEGORIES

USGS UNIT	NEED SURVEY		POLL. ABATEMENT		RED. FLOW FLUCT.		IMPROVE IRRIG.		IMPROVE COVER		STABILIZE BANK		BANK FENCING		RESTORE WATERSHED	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
17010205	87	6			36	1	186	6	84	6	160	5			268	11
17010206	188	16							75	4						
17010207	125	17							18	1	18	1			147	3
17010208	7	1	35	1	66	2									80	3
17010209	214	17			8	1									10	1
17010210	123	8	23	2					37	2	54	2	57	2	48	3
17010211	115	20									80	1	80	1	88	2
17010212					6	1							45	3	35	2
17010213	111	15							39	2	40	2	9	1	133	5
STATE TOT	6556	466	1380	61	1435	54	2326	67	2333	160	2432	140	756	37	3958	179

Table 12

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY FW&P DRAINAGE
MAN-CAUSED POLLUTION CATEGORIES

FW&P DRAINAGE	MINING RELATED		THERMAL EFFLUENT		COMM. CHEMICAL		COMM. ORGANIC		EXCESS SILT		IRR/RUNOFF RELATED		DOM. SEWAGE		DOM. STOCK		WEED/PEST CHEMICAL	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
01	47	2					4	1	289	18	111	4	56	6	73	13		
02	49	5			5	2			26	2	25	2	13	4	24	10		
03	57	2	31	1					249	9	177	6			55	6	144	4
04	5	1							362	15	188	4			285	9	135	3
05	149	12			100	1	100	1	316	11	256	15	181	3	242	19	168	2
06	24	4			61	1	80	2	318	10	231	10	241	6	410	25	62	2
07			77	3					74	7			66	4	50	3		
08			8	1					106	6					8	1		
09									163	13	91	7	57	11	7	5		
10	299	16							233	8	87	3	15	1	2	1	15	1
11	31	2	76	2					220	9	72	5	100	3	92	7		
12															2	2		
13	12	2							31	4			6	1	20	6		
14	2	1							29	2	111	18			64	3		
15	32	1							125	5	589	8	127	2	372	8		
16	13	1							491	12	48	1	186	4	120	4	43	1
17	285	14	184	4	38	2			868	36	394	23	64	11	8	5	23	2
18									17	2	128	3						
20									64	3	254	20			20	2	44	3
21																		
22	87	7							582	29	542	37	57	8	229	35	7	3
STATE	1092	70	376	11	204	6	184	4	4563	201	3304	166	1169	64	2083	164	641	21

Table 13

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY FW&P DRAINAGE
WATERSHED ABUSE CATEGORIES

DRAINAGE	ROAD CONST KM	ROAD CONST NO.	LOGGING KM	LOGGING NO.	MINING KM	MINING NO.	STOCK KM	STOCK NO.	GAME KM	GAME NO.	PEOPLE KM	PEOPLE NO.	OTHER KM	OTHER NO.
01	114	4			50	3	495	35			39	1	60	2
02	9	4	24	5	23	5	54	17						
03	94	12	348	22	92	3	225	11						
04	166	11	438	20	121	3	204	4						
05	650	35	726	48	102	8	263	16			9	1	6	1
06	193	9	273	17	25	5	134	7			8	1		
07	224	8	224	8			217	9						
08	376	16	517	25										
09	17	2	31	7			131	11			3	2		
10	78	5	9	2	260	13	126	4						
11	250	18	397	28	43	3	237	13						
12														
13	11	2	20	4	6	1	62	10						
14	6	2	2	1			37	3						
15							114	4						
16	21	1	52	3			312	10						
17	265	9	339	19	232	13	1211	60						
18			43	6			278	7						
20	6	1			29	1	31	3					98	5
21														
22	52	7	101	20	86	5	219	17			1	1	1	1
STATE	2512	146	3544	235	1069	63	4350	241			60	6	165	9

Table 14

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY FW&P DRAINAGE
WATER REMOVAL AND FLUCTUATION CATEGORIES

DRAINAGE	AGRIC. KM	AGRIC. NO.	POWER KM	POWER NO.	INDUSTRY KM	INDUSTRY NO.	MUNICIPAL KM	MUNICIPAL NO.	OTHER KM	OTHER NO.
01	554	26								
02	283	9					3	1		
03	357	16								
04	245	8					5	1	5	1
05	151	10			2	1	13	1	12	2
06	325	25			63	2	5	1		
07	134	8	95	4					6	1
08										
09	112	11					19	2		
10	344	18							18	1
11	246	14	76	2	21	1	33	2		
12										
13	64	4	84	3						
14	690	18								
15	768	14								
16	686	17	164	2						
17	716	34	240	8			11	2		
18	682	12								
20	292	12					13	1		
21	1008	10								
22	774	57	17	1			6	3	1	2
STATE	8431	323	676	20	86	4	108	14	42	7

Table 15

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NUMBER AND TOTAL LENGTH OF STREAM FISHERY REACHES REPORTED TO BE AFFECTED BY WATER QUALITY PROBLEMS
SUMMARIZED BY FW&P DRAINAGE
MANAGEMENT NEEDS AND RECOMMENDATIONS CATEGORIES

FW&P DRAINAGE	NEED SURVEY		POLL. ABATEMENT		RED. FLOW FLUCT.		IMPROVE IRRIG.		IMPROVE COVER		STABILIZE BANK		BANK FENCING		RESTORE WATERSHED	
	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.	KM	NO.
01	479	32	64	3	78	6	202	7	188	10	42	9	196	7	185	9
02	690	47	27	6	7	2			35	13	22	10				
03	87	6			36	1	186	6	84	6	160	5			268	11
04	207	22	121	3			79	3	271	7	255	7			391	17
05	132	20	211	6			100	1	278	21	218	19	9	1	443	18
06	224	16	160	3	56	2	196	6	52	4	61	6			230	6
07	245	29	58	3	72	3			37	2	134	3	182	6	251	10
08	527	50			8	1			93	5	18	1			157	4
09	200	21	61	4					70	4	64	7	20	1	68	4
10	235	15	274	11	123	3	195	5	49	1	53	3			15	1
11	445	36	95	4	64	2	43	3	78	23	98	6	57	4	431	25
12																
13	260	21			3	1			9	2	21	5			8	1
14					86	3	86	3	59	6	12	2			39	4
15	43	1			34	1	410	5	125	5	125	5	114	4	125	5
16	139	3	10	1	104	3	27	1	210	12	231	10	6	2	31	2
17	465	35	159	8	84	5	80	2	381	14	506	17	145	7	901	40
18	328	3			403	7	30	3	24	3	164	5			129	2
20					277	14	271	13	41	4	37	4			111	6
21	578	6					355	3								
22	1272	103	140	9			66	6	249	18	211	16	27	5	175	14
STATE	6556	466	1380	61	1435	54	2326	67	2333	160	2432	140	756	37	3958	179

3. Water Quality Inventory

The water quality data base currently available to the Department of Health and Environmental Sciences (DHES) was reviewed to determine the number and location of samples in which criteria for selected parameters have been exceeded. The data base of water quality records that was scanned for parameter "exceedences" consisted of 27,595 suitable surface water quality samples on the state's IBM 370 computer. This includes samples collected from 1973 through 1979 and analyzed by DHES; samples collected from 1971 through 1975 with a few samples dated earlier than this and analyzed by the Montana Bureau of Mines and Geology (MBMG); and samples collected from 1960 through 1977 and on EPA's STORET system under the agency code for the U.S. Geological Survey. These last data had been reformatted for use on the state's computer system.

The statewide distribution of exceedences for each parameter was displayed on a Montana river system base map obtained from the U.S. Geological Survey. A total of 25,975 samples had the latitude-longitude information necessary for plotting locations on an invisible grid. Water quality maps were generated by overlaying the computer plots on the USGS base map. The plotting is done by a computer program developed by the Montana Department of Community Affairs. This program applies an adjustment for the curvature of the earth in determining the actual plot locations.

The USGS data tend to consist of a large number of samples at a small number of locations. The remainder of the data are scattered over a large number of locations, with only a small number of samples at a particular location. There are exceptions to this, namely areas of intensive study such as acid-mine drainages and below industrial discharges.

The following sections discuss the significance of exceedence distributions displayed in Figures 4 through 12. A detailed listing of all samples in which these parameters exceeded their criteria is on file at the Water Quality Bureau, DHES.

Water Quality Sampling Sites (Figure 4). The first map to be generated was that of all suitable sampling stations in the data base. This map gives an idea of the distribution of surface water quality sampling efforts to date in Montana. And it will serve in comparing exceedence patterns with sampling patterns. The map of water quality sampling sites shows concentrated effort in western Montana, particularly the Flathead, upper Clark Fork, and upper Missouri River drainages. On the other hand, the pattern is relatively light over most of northeastern Montana, perhaps reflecting both the aridity of this region and its geographical seclusion. Certain special studies become evident by the concentrations of sample sites, notably the ASARCO-Troy study in the Lake Creek drainage of the Kootenai River basin. Other studies were deliberately extensive rather than intensive and are less conspicuous on the map. An example is the saline seep inventory of the Montana Plains by the DHES and the MBMG.

pH (Figure 5). The great majority of the 605 samples in which pH values were below the lower limit (6.5) were collected in western Montana. A large number of these low pH readings are apparently of natural origin, notably

Figure 1. Surface-water quality sampling sites

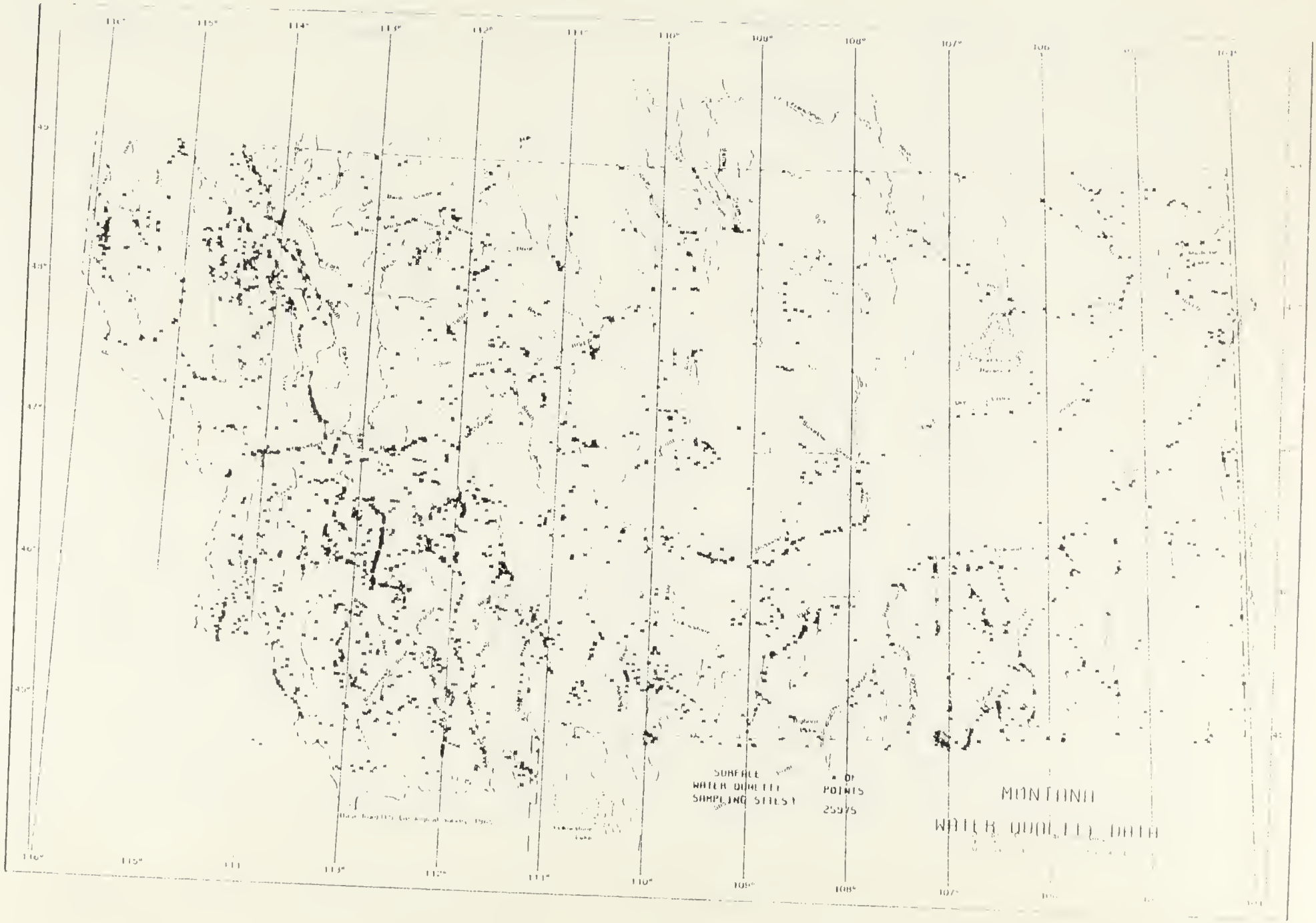
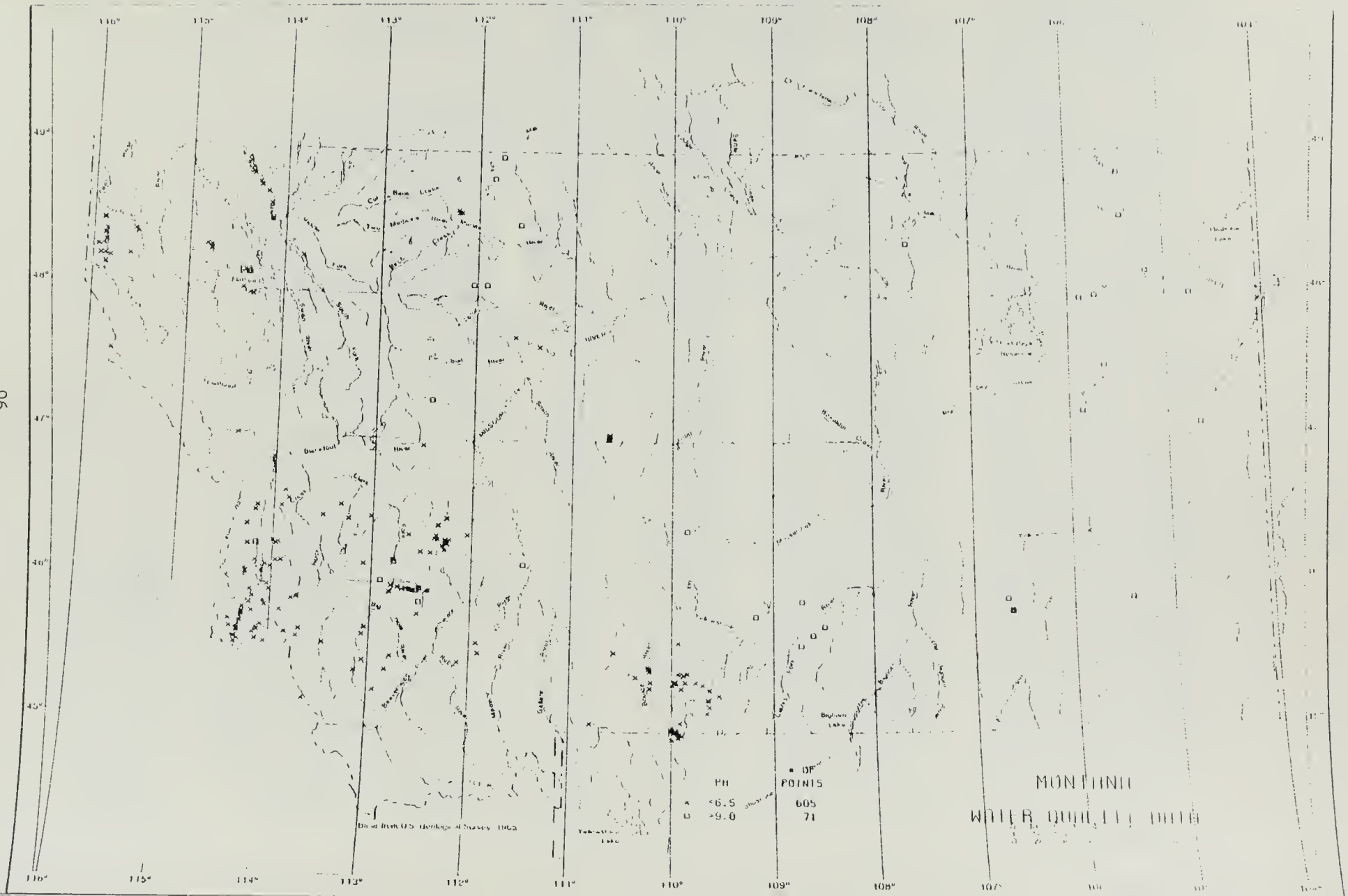


Figure 5. Sampling sites where pH exceeded its criteria (6.5-9.0)



in the Bitterroot, Lake Creek, North Fork Flathead, and upper Stillwater River drainages. Also conspicuous are certain concentrations of acid-mine drainage problems, including the northern Boulder Batholith, the Hughesville area in west-central Montana, and Soda Butte Creek near the northeast tip of Yellowstone Park. The high pH readings (greater than 9.0), mostly in eastern Montana, probably reflect the naturally alkaline and productive waters generally encountered in this part of the state.

Temperature (Figure 6). Two temperature criteria were applied: one for cold water basins in western Montana (19°C) and one for warm water basins in eastern Montana (28°C). Exceedence patterns in western Montana reveal several "hot spots." Most evident are the Silver Bow Creek-Upper Clark Fork River system, the West Fork of the Bitterroot River, the Clark's Fork of the Yellowstone River, and the lower reaches of several streams in the Flathead Valley. No conspicuous patterns developed in eastern Montana.

Dissolved Oxygen (Figure 7). Two D.O. criteria were applied: one for cold water basins in western Montana (7 mg/l) and one for warm water basins in eastern Montana (5 mg/l). The only significant concentration of low D.O. values was centered on lower Ashley Creek in the Flathead Valley. This segment of Ashley Creek receives the treated wastewater from the City of Kalispell and is classified E-F (E).

Turbidity (Figure 8). Turbidity exceeded the 100 NTU limit in 450 samples. Notably turbid waters were the Musselshell River and the Yellowstone River system from the Clark's Fork downstream. These waters are naturally turbid, particularly during runoff, but in both cases turbidity is enhanced by accelerated streambank erosion stemming from hydrologic modifications and poor land use practices. A strong turbidity pattern also was evident in the headwaters of the Blackfoot River in western Montana, probably in the North Fork and Landers Fork of the Blackfoot, which suffer heavy sediment loads as the result of unstable banks and naturally unstable soils in their drainages. Mining activities also have exacerbated turbidity problems in the upper Blackfoot River drainage.

Suspended Solids (Figure 9). Much the same pattern shown by turbidity was expressed for suspended solids. These are companion measurements that often are run in tandem. Suspended solids exceedence patterns tend to substantiate the sediment problems displayed on the turbidity map. More evident on the suspended solids map is a concentration of exceedences in the upper Clark Fork River system.

Specific Conductance (Figure 10). The specific conductance limit (3,000 µmhos/cm) was chosen because it represents the upper practical limit for irrigation under normal conditions. Two types of patterns emerge on the exceedence map for specific conductance. One pattern follows stream courses, notably Silver Bow Creek in southwest Montana, and Armells, Otter, and Hanging Woman creeks in southeast Montana. The other type of pattern is more diffuse, reflecting saline seep areas surveyed by the DHES and the MBMG. Two saline seep "hot spots" stand out: the internally-drained Wheat Basin in northern Stillwater County between the Yellowstone and Musselshell rivers, and the Highwood Bench area east of Great Falls and south of the Missouri River.

Figure 6. Sampling sites where temperature exceeded its criteria (19°C - cold basins; 28°C - warm basins)

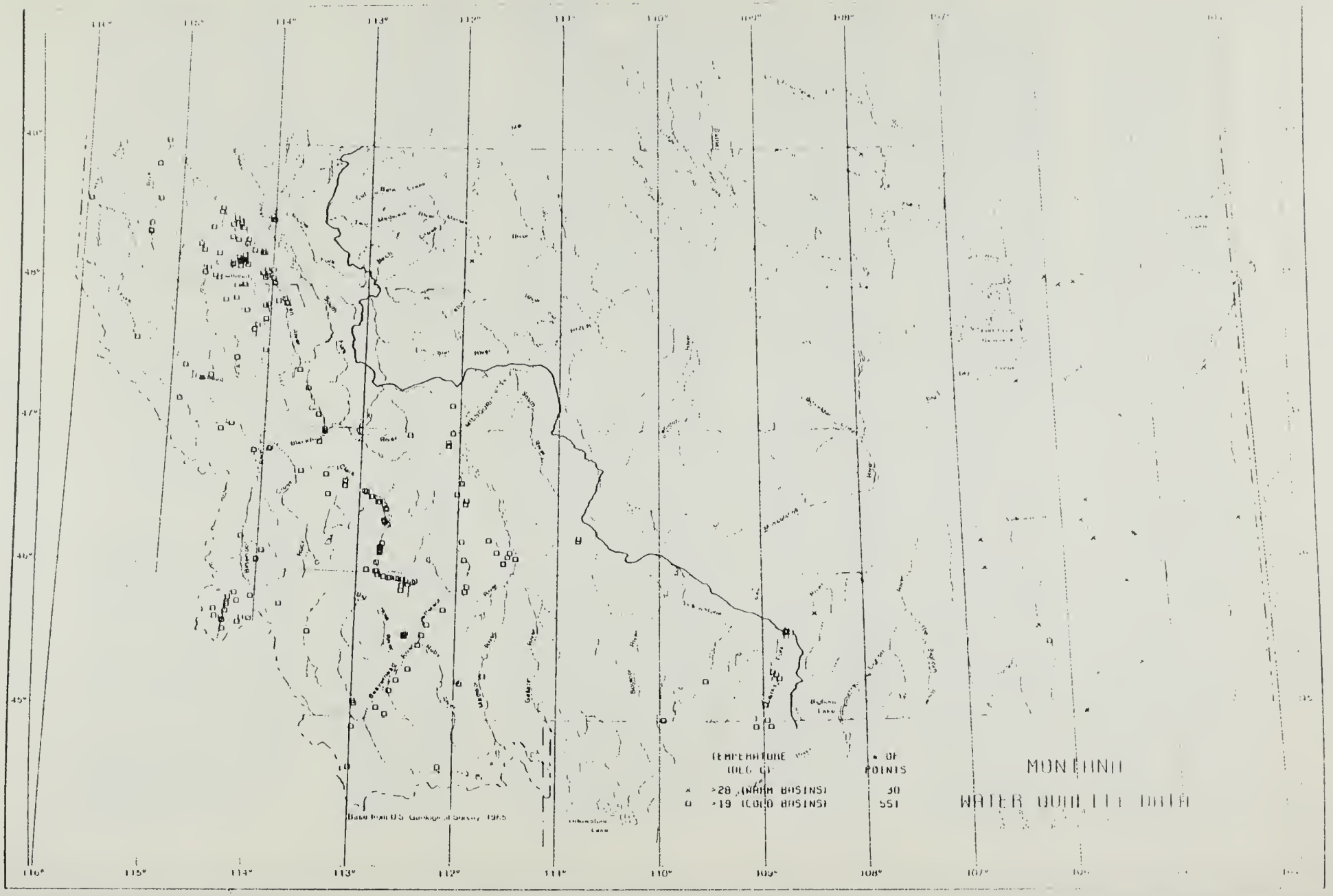


Figure 7. Sampling sites where dissolved oxygen exceeded its criteria (7 mg/l - cold basins; 5 mg/l - warm basins)

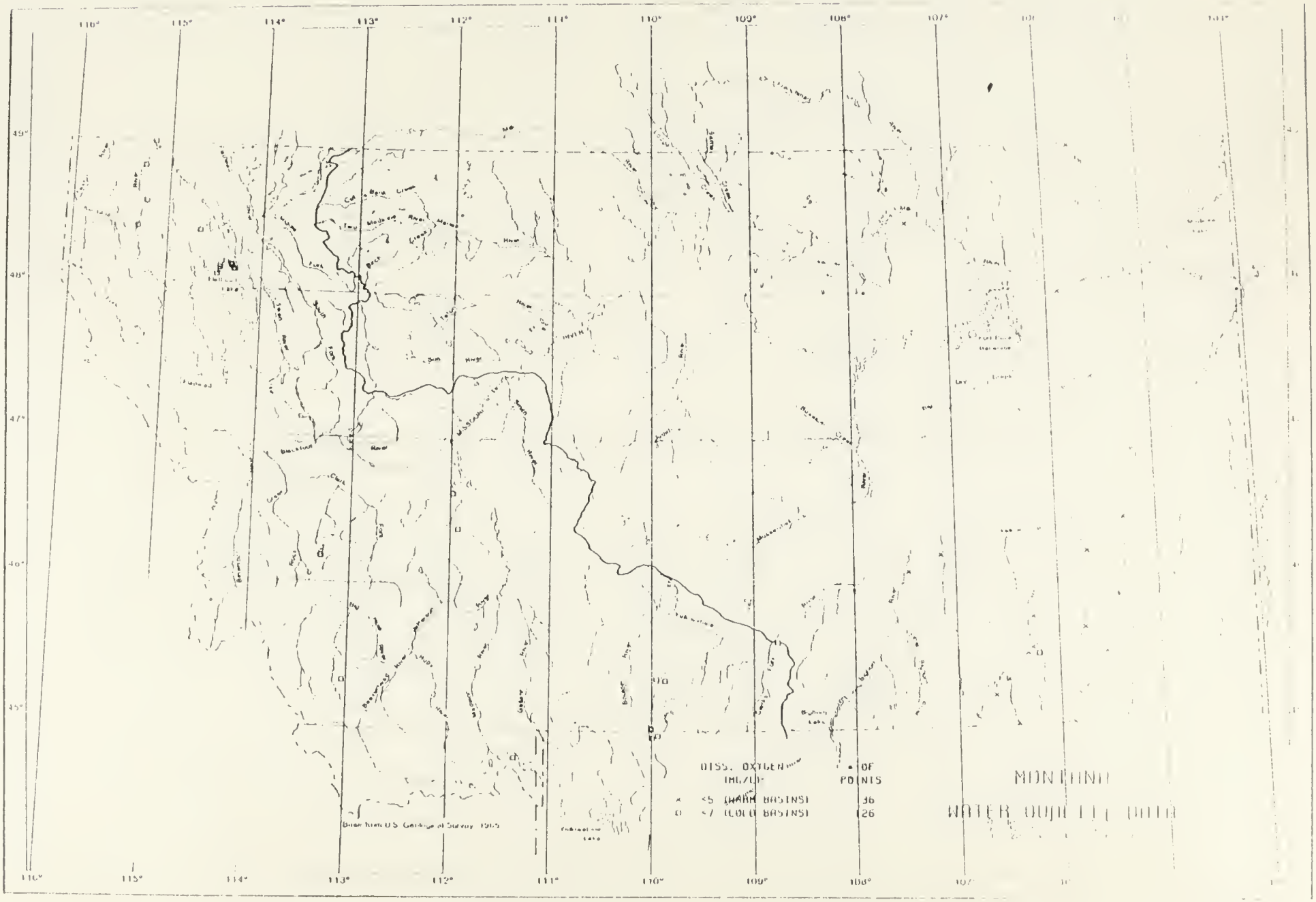


Figure 8. Sampling sites where turbidity exceeded its criterion (100 NTU)

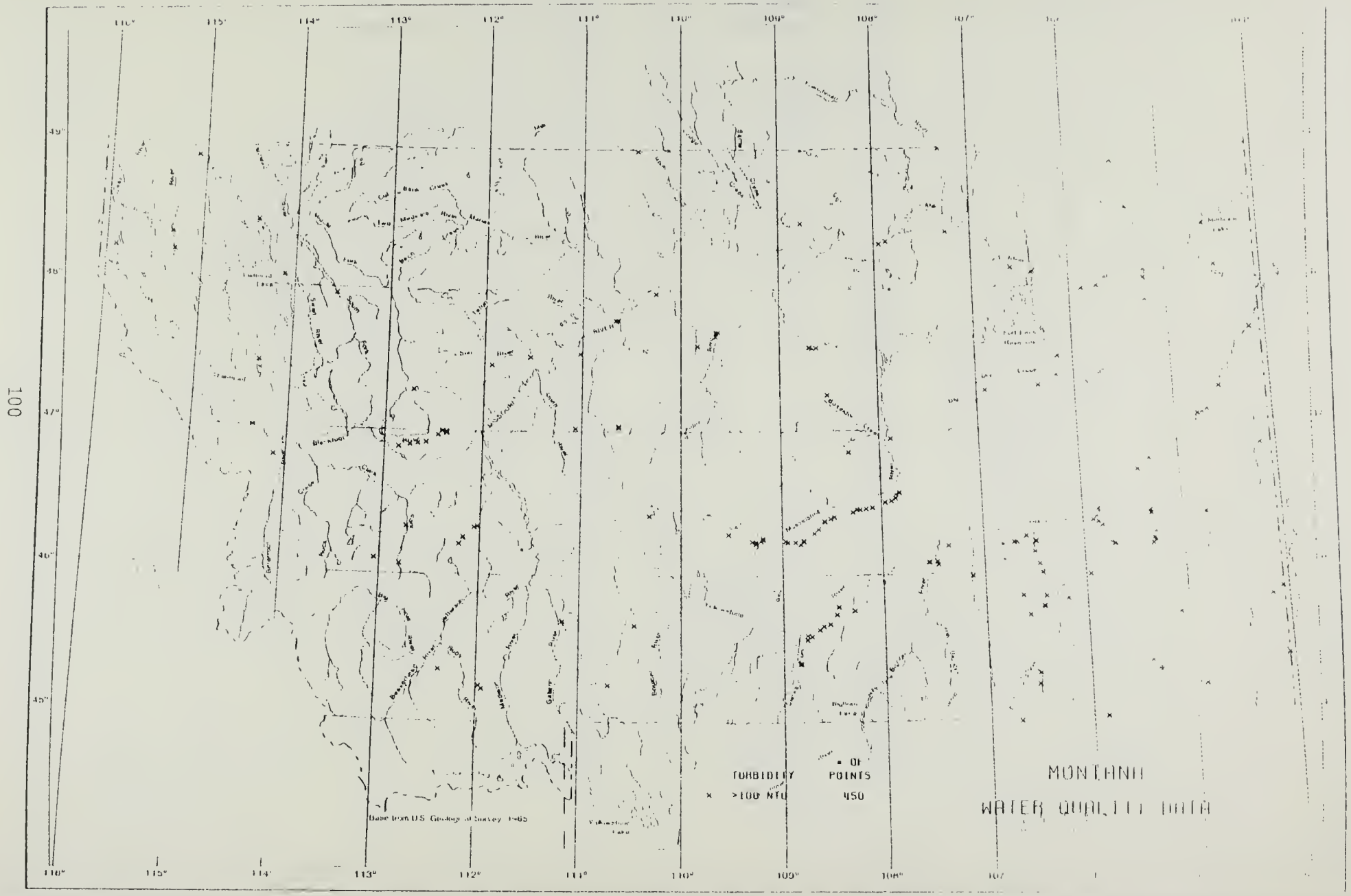


Figure 9. Sampling sites where suspended solids exceeded its criterion (250 mg/l)

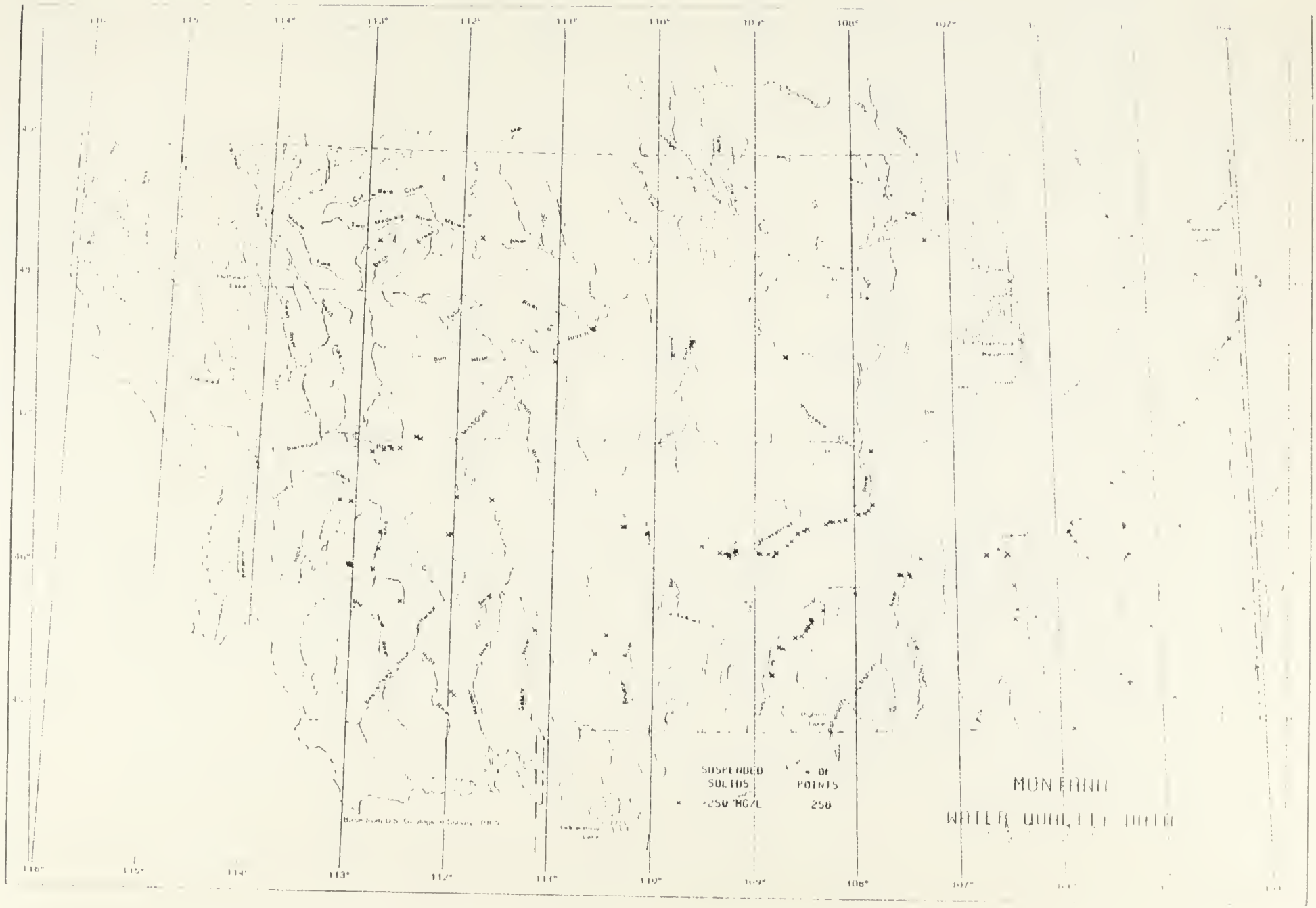
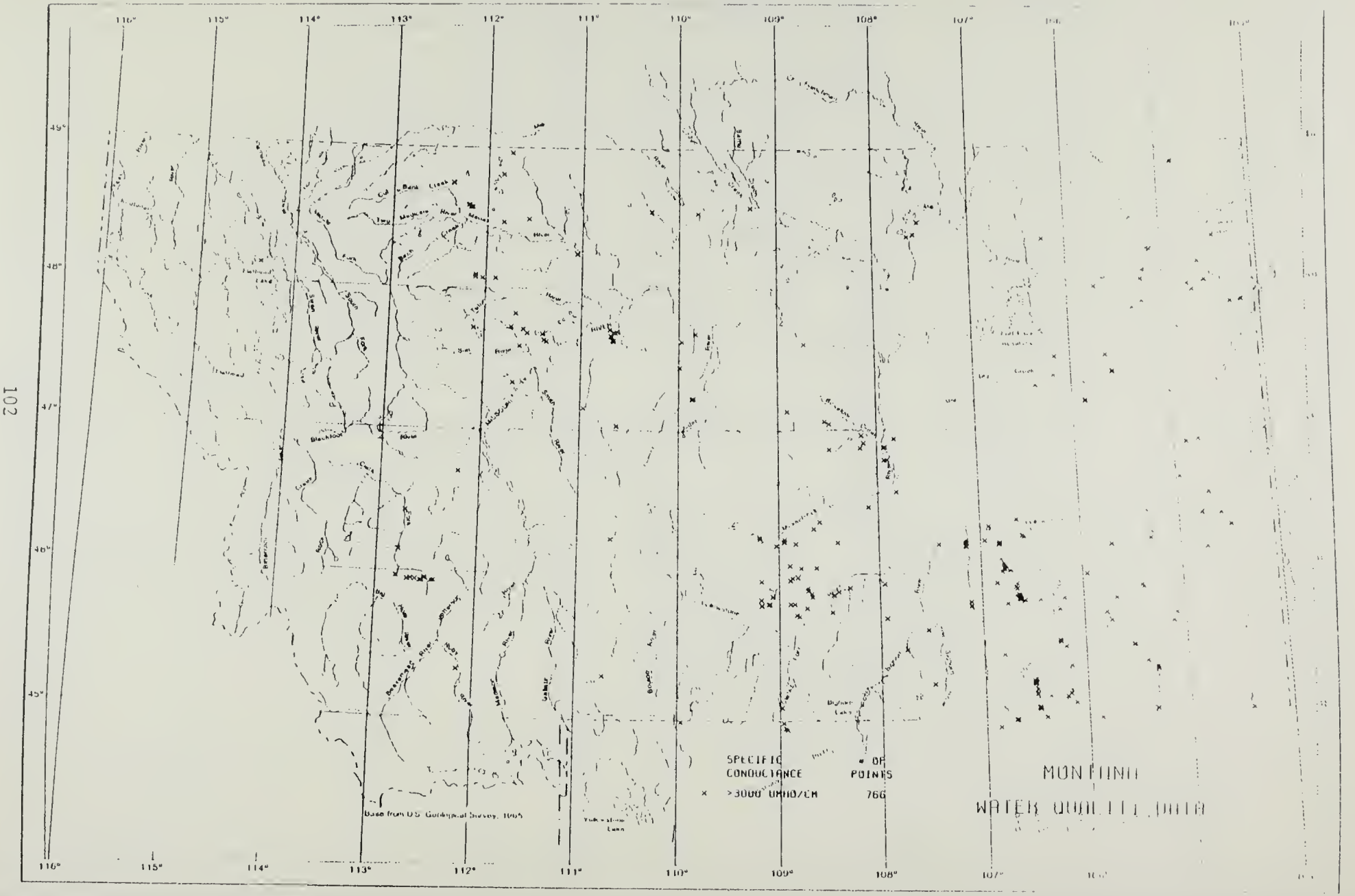


Figure 10. Sampling sites where specific conductance exceeded its criterion (3000 µmhos/cm)



Total Dissolved Solids (Figure 11). Total dissolved solids exceedence patterns tend to parallel and substantiate salinity problems displayed on the specific conductance map.

Nutrients (Figure 12). Points on this map represent exceedences for both nitrogen (0.35 mg/l TSIN) and phosphorus (0.05 mg/l TP). Above these levels, nuisance algal growths are likely to occur in running waters, other factors being favorable. The striking feature on this map is the intense pattern of exceedences along Silver Bow Creek and the upper Clark Fork River, stemming largely from municipal discharges (Butte, Anaconda, Deer Lodge) and natural sources (Phosphoria Formation). Other nutrient "hot spots" are Ashley Creek (below the Kalispell STP), the East Gallatin River (below the Bozeman STP), Prickly Pear Creek (below the Helena STP), and the Yellowstone River (below the Billings STP). The concentration of exceedences just below the headwaters of the Missouri River reflects the Crow Creek irrigation unit near Toston. The heavy pattern in the Highwood Bench area is saline seep related. It is also evident that much of the Yellowstone River system in southeastern Montana consists of naturally fertile waters.

Figure 11. Sampling sites where total dissolved solids exceeded its criterion (2000 mg/l)

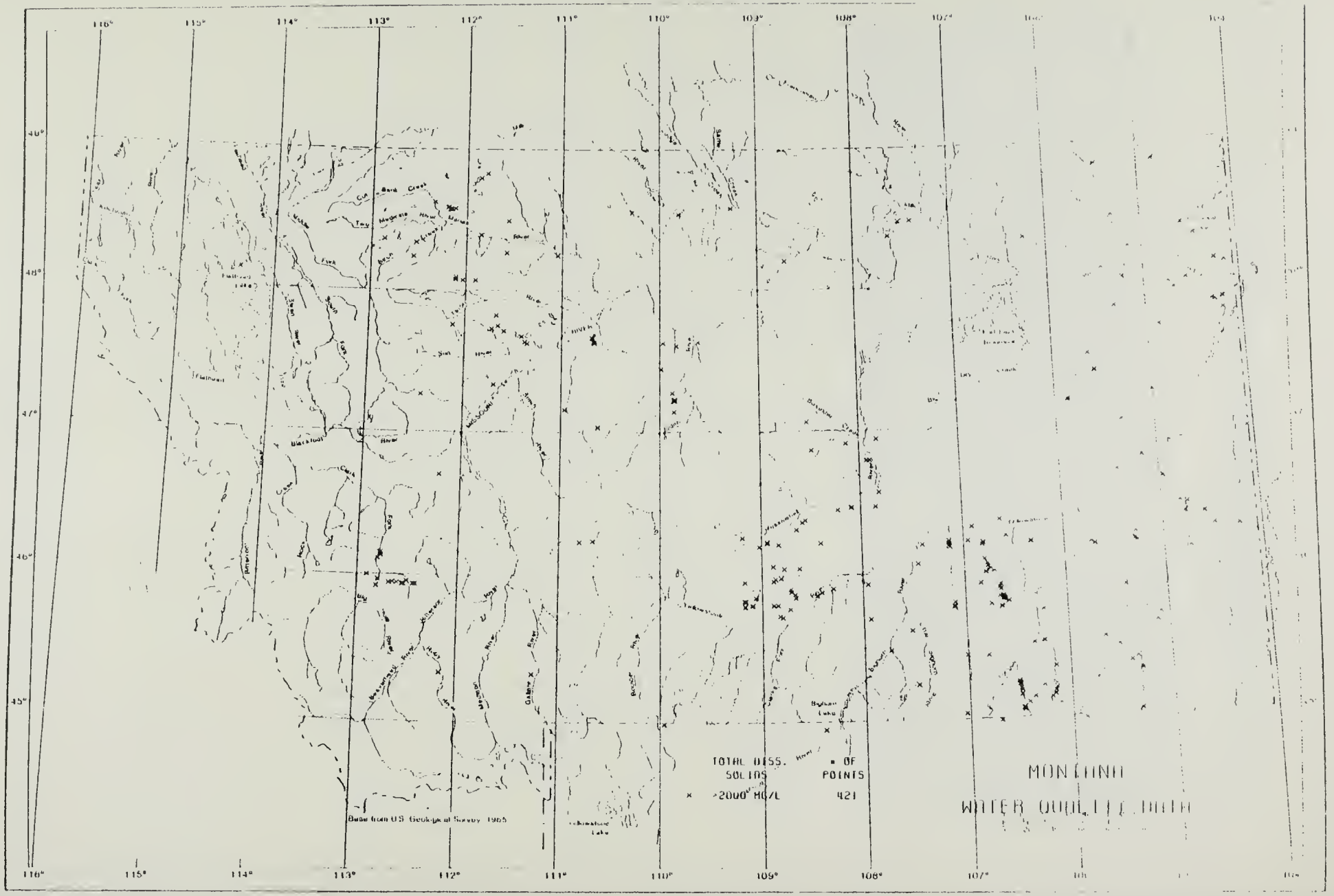
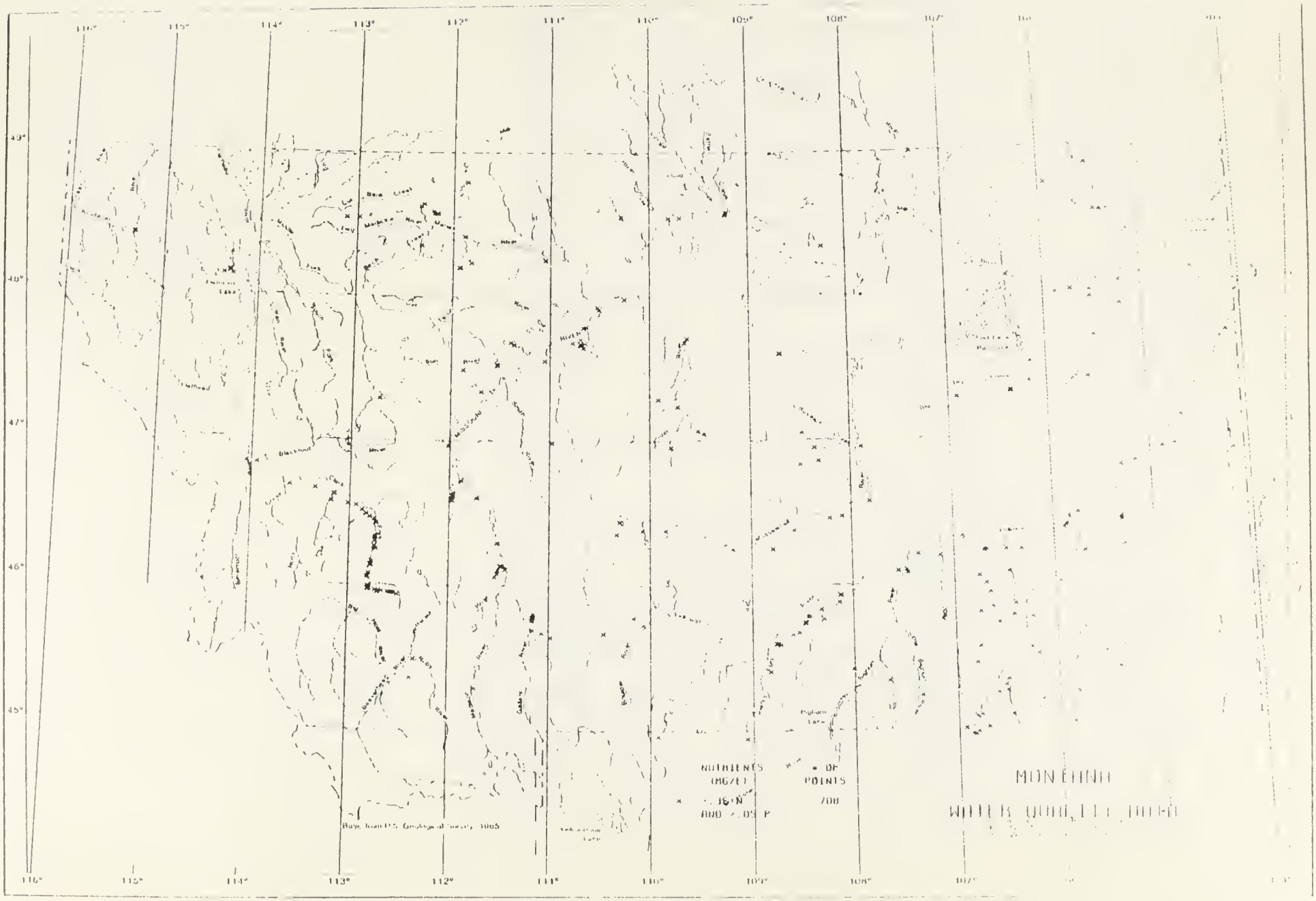


Figure 12. Sampling sites where algal nutrients exceeded their criteria (0.35 mg/l N and 0.05 mg/l P)



4. Point Source Inventory

Montana's wastewater discharge permit program began in 1968. With passage of P.L. 92-500 (Water Pollution Control Amendments of 1972), a federal wastewater discharge permit program also was initiated. In 1974, Montana applied for and received authority from EPA to administer this program, thus minimizing duplication of effort. EPA established wastewater discharge limitations for the various categories. Where these limitations will not allow the meeting of water quality standards (including nondegradation of high quality waters by new discharges or existing industries), stricter limitations are imposed.

Major municipal and industrial dischargers were reviewed for their present instream effects on water quality. It was assumed that minor discharges are not significantly affecting water quality; however, there may be exceptions to this assumption, particularly regarding ammonia from minor municipal discharges. A number of municipal discharges are now being assessed for potential ammonia toxicity problems. (See Chapter IV. Section F., Special Water Quality Problems--Ammonia.)

Problems are summarized in Tables 16 and 17. A "problem" is defined as a situation where one or more water quality criterion is being exceeded. It does not necessarily mean that water quality standards are being violated. Where receiving waters are classified E-F (E)--Silver Bow Creek, Ashley Creek, Prickly Pear Creek--standards are not being violated, however in other cases they are. Only problems directly associated with permitted discharges are considered; other problems such as spills and contamination of subsurface aquifers, are not addressed. The construction grants status and designated treatment requirements of Montana's major municipal dischargers are presented in Table 18.

The updated assessment presented in Tables 16, 17 and 18 was provided by Mr. Richard Montgomery, EPA permits and enforcement engineer for Montana. It should be noted that only those problems currently known to Mr. Montgomery are indicated in the tables that follow; failure to identify a problem does not necessarily mean that one does not exist.

Table 16. A current assessment of water quality problems caused by major industrial dischargers in Montana.

Discharger	Permit No.	Receiving Stream	Problem
The Anaconda Company, Great Falls	MT-0000493	Missouri River	none
Phillips Petroleum Co., Great Falls	MT-0000434	Missouri River	none
The Anaconda Company, Butte	MT-0000183	Silver Bow Creek	pH, metals
The Anaconda Company, Anaconda	MT-0000191	Clark Fork River	sulfate, metals
Hoerner Waldorf Corp., Missoula	MT-0000035	Clark Fork River	color
J.R. Daily, Missoula	MT-0000094	Clark Fork River	none
Great Western Sugar, Billings	MT-0000281	Yellowstone River	none
Burlington Northern, Inc., Livingston	MT-0000388	Yellowstone River	none
Farmers Union Central Exchange, Laurel	MT-0000264	Yellowstone River	none
Continental Oil Company, Billings	MT-0000256	Yellowstone River	none
Exxon, Billings	MT-0000477	Yellowstone River	none
Montana Power Company, Billings	MT-0000396	Yellowstone River	none
Holly Sugar Company, Sidney	MT-0000248	Yellowstone River	none
Montana-Dakota Utilities, Sidney	MT-0000302	Yellowstone River	none
St. Regis Paper Company, Libby	MT-0000221	Kootenai River	aesthetic

Table 17. A current assessment of water quality problems caused by major municipal dischargers in Montana.

Discharger	Permit No.	Receiving Stream	Problem
City of Bozeman	MT-0022608	East Gallatin River	ammonia, oxygen, nutrients
City of Dillon	MT-0021458	Beaverhead River	coliforms, possible ammonia
City of Missoula	MT-0022594	Clark Fork River	possible ammonia
Silver Bow Metro SID #1	MT-0022012	Silver Bow Creek	ammonia, nutrients
City of Hamilton	MT-0020028	Bitterroot River	none
City of Deer Lodge	MT-0022616	Clark Fork River	nutrients
City of Kalispell	MT-0021938	Ashley Creek	ammonia, nutrients, oxygen
City of Columbia Falls	MT-0020036	Flathead River	none
City of Polson	MT-0020559	Flathead River	none
City of Whitefish	MT-0020184	Whitefish River	nutrients
City of Billings	MT-0022608	Yellowstone River	nutrients
City of Livingston	MT-0020435	Yellowstone River	none
City of Laurel	MT-0020311	Yellowstone River	none
City of Great Falls	MT-0021920	Missouri River	none
City of Helena	MT-0022641	Prickly Pear Creek	ammonia, coliforms, nutrients
City of Havre	MT-0022535	Milk River	possible ammonia, coliforms, chlorine residual
City of Glasgow	MT-0021211	Milk River	none
City of Miles City	MT-0020001	Yellowstone River	none
City of Baker	MT-0022381	Sandstone Creek	secondary plant inoperable
City of Glendive	MT-0021628	Yellowstone River	none
City of Libby	MT-0020494	Kootenai River	none
City of Hardin	MT-0020834	Bighorn River	none
City of Conrad	MT-0020079	Dry Fork, Marias River	possible ammonia
City of Cut Bank	MT-0020141	Cut Bank Creek	possible ammonia
City of Lewistown	MT-0020044	Big Spring Creek	possible ammonia
City of Wolf Point	MT-0020532	Missouri River	none

Table 18. Construction grants status and treatment requirements of major municipal dischargers as of May 27, 1980.

City	Status	Percent Completion (Construction)	Treatment Requirements
Bozeman	D		Secondary treatment and advanced waste treatment
Dillon	FP		Improvements to meet secondary treatment
Missoula	FP		Improve sludge handling; possible chlorine and ammonia removal
Butte	C	98	Upgrade secondary treatment and sludge disposal
Hamilton	FP		Upgrade to secondary treatment
Deer Lodge	FP		Upgrade to secondary with possible phosphorus removal
Kalispell	FP		Sludge disposal and advanced waste treatment
Columbia Falls	D		Replace existing treatment plant and improve sludge handling facilities
Polson	D		Upgrade to secondary treatment
Whitefish	C	60	Upgrade to secondary treatment
Billings	C	80	Odor removal
Livingston	D/C	bond sales	Upgrade to secondary treatment
Laurel	FP		Upgrade to secondary treatment
Great Falls	----------no active project----------		
Helena	FP		New sludge treatment and disposal and increase reliability of existing facility
Havre	FP		Provide dechlorination
Glasgow	----------no active project----------		
Miles City	C	25	Upgrade to secondary treatment

City	Status	Percent Completion (Construction)	Treatment Requirements
Baker	----------no active project----------		
Glendive	----------no active project----------		
Libby	FP		Upgrade to secondary treatment
Hardin	C	60	Upgrade to secondary treatment
Conrad	----------no active project----------		
Cut Bank	FP		Improve treatment and replace old equipment
Lewistown	FP		Upgrade to secondary treatment
Wolf Point	FP		Upgrade to secondary treatment and expand

FP = Facility Plan (Step 1)

D = Design (Step 2)

C = Construction (Step 3)

Tables 19 and 20 list the various categories of major and minor industrial wastewater discharges and their recent status with regard to compliance and enforcement. Most of the projects shown as inactive have eliminated their discharges to surface waters and therefore do not need a wastewater discharge permit.

Table 21 lists the status of the municipal discharges. Montana's five largest cities (Billings, Great Falls, Butte, Missoula and Helena) all have treatment facilities capable of meeting effluent limitations except for chlorine residual and fecal coliform bacteria. There are discharge limitations on chlorine residual because of its toxic effect on aquatic life, and meeting these limiations generally does not allow the municipality to meet the fecal coliform limits. Billings is presently experimenting with high chlorination followed by dechlorination with sulfur dioxide which appears to give acceptable results.

Many of the communities meeting discharge limitations still have treatment facility needs. For example, Helena, Kalispell and Missoula all need improvements to their sludge disposal practices. The discharge standards for sewage lagoons were relaxed during the past year by EPA and, hopefully, this will allow many of the smaller communities to meet effluent limitations with a minimum amount of improvements.

Table 19. Status of major industrial wastewater discharge permittees as of September 1979.

Category	Total No.	Active	Inactive	Substantially In Compliance	Not In Compliance
Smelters	3	3	0	1	2 (see note 1 below)
Railroads	1	1	0	0	1 (see note 2 below)
Plywood Mills	1	1	0	1	0
Oil Refineries	4	4	0	2	2 (see note 3 below)
Slaughter Plants	1	1	0	1	0
Sugar Refineries	2	2	0	1	1 (see note 4 below)
Paper Mills	1	1	0	1	0 (see note 5 below)
Generating Plants	2	2	0	1	1 (see note 6 below)
Totals	15	15	0	8	

1. Anaconda-Great Falls - Not meeting effluent limitations. Enforcement action taken. On schedule to comply by 1/1/80.
   Anaconda-Warm Springs- Not meeting all permit limits; compliance report being prepared.
2. B.N.-Livingston - Permit limit violations. Envorcement action taken. On schedule to comply by 1/1/80.
3. Exxon - Permit limit violations and oil spill. Enforcement action taken.
   Farmers Union - Permit limit violations. Enforcement action taken.
4. G.W. Sugar - Permit violations and dike failure. Enforcement action underway.
5. Hoerner Waldorf - Enforcement action underway for past dike break.
6. MDU-Sidney - Enforcement action taken. Presently eliminating discharge which was in violation.

Table 20. Status of minor industrial wastewater permittees as of September 1979

Category	Total No.	Active	Inactive	Substantially In Compliance	Not In Compliance	
Fish Farms	19	10	9	10	0	
Irrigators	19	0	19	0	0	Considered nonpoint sources under Federal legislation
Feed Lots	156	147	9	147	0	See note 1 below
Oil Wells	60	7	53	7	0	
Mines	25	18	7	18	0	
Smelters	2	1	1	1	0	
Dairies	1	0	0	0	0	
Railroads	11	7	4	5	2	See note 2 below
Lumber and Plywood Mills	2	1	1	1	0	
Oil Refineries	3	1	2	1	0	
Highway Projects	36	19	17	19	0	
Sand & Gravel	4	1	3	1	0	See note 3 below
Slaughter Plants	1	0	1	0	0	
Cement Plants	2	2	0	2	0	
Chemical Plants	2	1	1	1	0	
Generating Plants	1	1	0	1	0	
Industrial Sewage Treatment Plants	8	8	0	8	0	Mt. Power Dam Plants
Miscellaneous	17	7	10	7	0	
Totals	369	231	138	229	2	

1. Includes 98 smaller feedlots on state permit program but not included as part of federal permit program.

2. Enforcement action against BN, Havre taken. Presently meeting compliance schedule. Compliance order to be issued to BN Whitefish for recent permit violations.

3. Enforcement action against Empire Sand and Gravel Co. underway for past violations. Company has not constructed any discharge system.

Table 21. Status of municipal and federal wastewater discharges as of September 1979.

	Substantially In Compliance		Not in Compliance With Secondary Treatment Standards	
Sewage Treatment Facilities	Major	Minor	Major	Minor
Municipal & State	9	71	16**	54
Federal & Indian	-	30	1	4
Totals	9	101*	17	58
Water Treatment Facilities				
Municipal	-	9	-	4
Federal & Indian	-	1	-	0
Totals		10*		4

*About 1/2 of these have no surface water discharges.

**Enforcement Action against Bozeman by EPA in Federal District Court.

5. Nonpoint Source Inventory

a. Statewide 208 area

The following discussion attempts to summarize nonpoint source problems in drainage basins covered under the Statewide 208 plan. These problems were identified primarily through the use of questionnaires to Conservation Districts, on-site inspections and surveys, and discussions with responsible state and federal agencies who contributed to the Statewide 208 water quality assessment.

It should be pointed out that most of this information is currently available in the November, 1978 Statewide 208 document entitled Montana Statewide 208 Surface and Ground-water Quality Assessment and Management Alternatives. Although the information presented in this 305(b) report is fairly general and often lacks the detail necessary to relate land management activities to water quality problems, more specific information may be found for certain nonpoint source problem catagories (forestry, mining) in numerous Statewide 208 reports (see Section VII). In addition, this deficiency is presently being addressed through a process of updating the original Conservation District assessments to include more site-specific problem identification. The initial results of these updates will be available by June, 1980 and they will form a specific list of identified problem areas toward which future 208 funding will be directed.

The nonpoint source problems identified in the following section include the catagories of agriculture, forestry, and mining. Streambank erosion due to various man-related activities is also identified by major basin. These major basins in the Statewide 208 planning area are shown in figure 13.

Agriculture

Agricultural land use and associated practices are considered to be the most significant sources of nonpoint pollution in Montana. Of the nonpoint source pollutants associated with agriculture (which include sediment, salts, pesticides and nutrients), sediment is considered the most critical problem. Although somewhat cursory, this prioritization is based on the following facts:

(1) Soil erosion is the dominant problem on 57 percent of Montana's agriculture land (Conservation Needs Inventory 1970).

(2) Channel erosion is the major source of sediments. "Man-caused" bank erosion comprises 68 percent of the assessed total. Of all bank erosion, one-third is the result of agricultural activities, mostly grazing and tillage (MACD Ag-NPS Inventory, 1978).

(3) Agriculture accounts for 82 percent of the land use in the state, and by mere size it contributes most of the geologic and man-caused nonpoint source pollutants.

(4) Department of Fish, Wildlife and Parks stream inventories of fisheries resources conclude that agriculture-induced sedimentation is the most significant factor limiting fisheries in Montana streams.

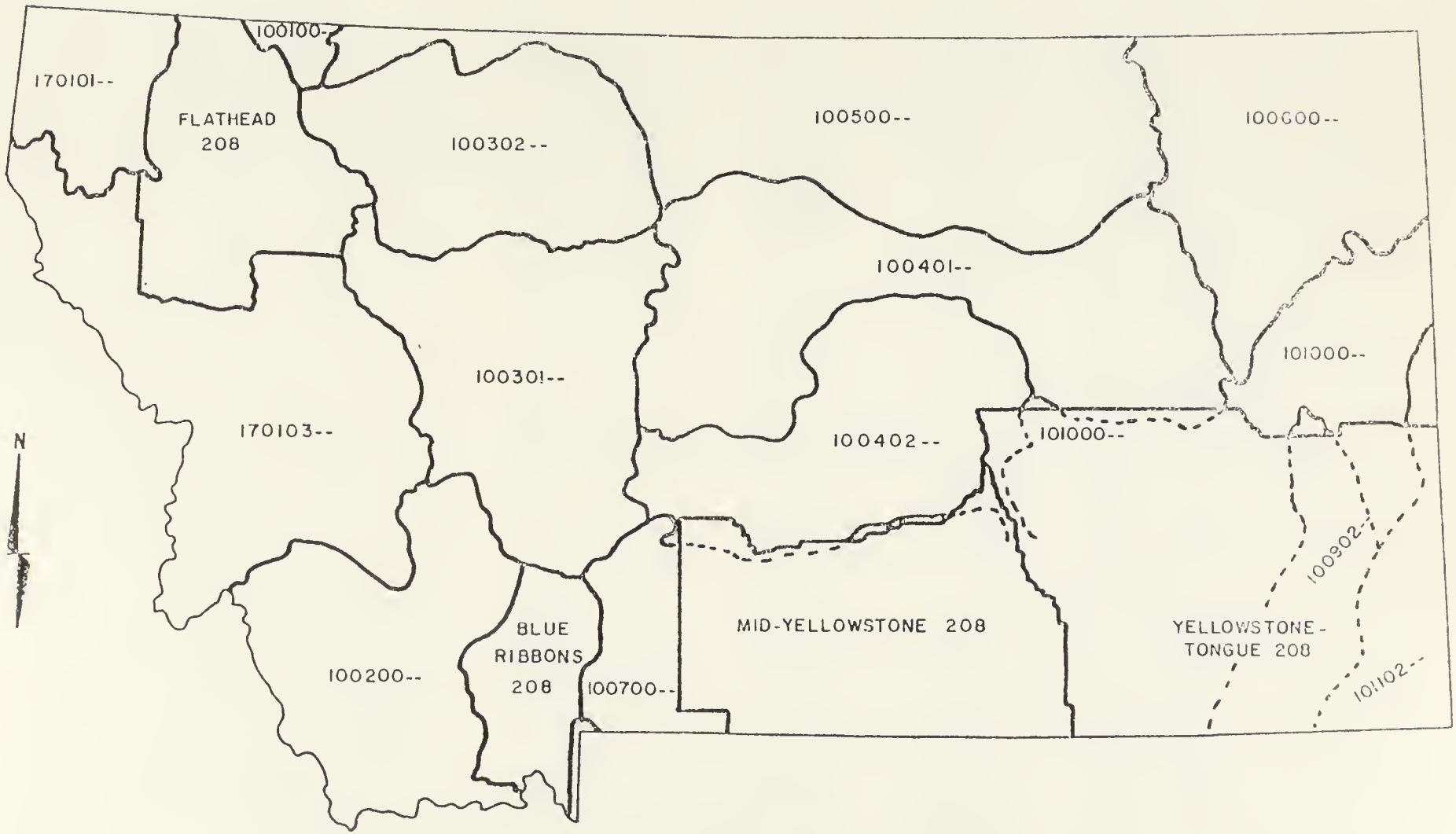


Figure 13 Basin delineations used in Conservation District inventory.

Early in the Statewide 208 program a contract was developed with the Montana Association of Conservation Districts (MACD) for an assessment of agriculture nonpoint source problems. The first step of that assessment was development of a questionnaire to identify areas where agricultural activities were known or suspected to be causing water quality degradation. The Statewide Sediment Control Project, MACD, and the Water Quality Bureau worked cooperatively to revise the Sediment Project questionnaire to cover streambank erosion, salinity, and confined feeding operations. The questionnaires were then distributed to each district in the Statewide 208 study area for completion. The information was compiled and mapped by subdrainage basin as delineated by the U.S.G.S. Hydrologic Unit Map, 1974. Figure 13 identifies basins in the study area; Figure 14 (map pocket) is a depiction of the Districts' data.

The Statewide 208 study area covers 60,880,091 acres. Table 22 shows the acreage totals for each major drainage basin. The Conservation Districts estimated about 72 percent of the project area, 43,797,138 acres, is being used for agricultural purposes. Rangeland and pasture make up about 71 percent of the agriculture land; the remainder is classed as dry or irrigated cropland.

Viewed geographically, a majority (about 82 percent) of the agricultural land is in the Great Plains area east of the Continental Divide. Data from the District survey also indicate only about 14 percent of land west of the Continental Divide (Kootenai and Clark Fork Basins) is used for agricultural purposes while 85 percent of the plains area (remaining basins) is devoted to agricultural use.

Sediment-water erosion--Tables 23-25 show acreages for each major agricultural land use and the degree of soil erosion in each basin as reported by the Conservation Districts. The majority of soil erosion by water occurs on dry cropland. Thirty-four percent of the dry cropland in the Statewide 208 study area (3,667,225 acres) is experiencing some degree of water erosion. About 16 percent (4,870,591 acres) of rangeland has some degree of soil loss by water. Only 8 percent (144,403 acres) of the irrigated acres are experiencing water erosion.

Depending on the way in which the Conservation District data are compiled, apparent impacts of agriculture-related soil erosion on water quality are significantly changed. For example, the fact that the Districts estimate soil is being removed by water from 8,682,219 acres in the Statewide 208 study area is, in itself, dramatic; however, that figure cannot be used alone to describe water quality impacts due to water erosion. That acreage represents only about 15 percent of the study area and only about nine percent of the entire state. Also, the figure obviously does not indicate the length of time those acres are eroding, how much soil is being removed, and most importantly, how much of the lost soil is actually entering water bodies to the detriment of their quality. The most that can be said of Ag-NPS sediment pollution from the Districts' data is that the potential for detrimental impact due to water erosion in the Statewide 208 study area is significant.

Sediment-streambank erosion--Table 26 summarizes the Districts' data on streambank erosion. Thirty-two percent of all streambank erosion was considered

TABLE 22

DRAINAGE BASIN ACREAGES

CONSERVATION DISTRICT INVENTORY FOR THE STATEWIDE 208 AREA

BASIN	USGS NUMBER	TOTAL ACRES
Kootenai	170101	2,299,400
Clark Fork	170102	8,724,249
Jefferson	100200	6,052,264
Madison	100200	250,364
Upper Yellowstone	100700	1,607,588
Upper Missouri	100301	6,595,110
Marias	100302	4,617,580
Middle Missouri	100401	8,585,710
Musselshell	100402	5,664,680
Milk	100500	8,347,020
Lower Missouri	100600	4,621,956
Lower Yellowstone	101000	3,204,770
Lower Tongue	100902	67,200
Beaver	101102	242,200
		60,880,091

TABLE 23

WATER EROSION ON DRY CROPLAND

IN THE STATEWIDE 208 STUDY AREA

BASIN	ACRES IN DRY CROPLAND & % OF BASIN TOTAL	ACRES WITH SLIGHT-SEVERE EROSION & % BASIN LAND USE TOTAL
Kootenai	6,820 (1%)	20 (<1%)
Clark Fork	79,827 (1%)	19,220 (24%)
Jefferson	77,832 (1%)	13,185 (17%)
Madison	2,500 (1%)	50 (<1%)
Upper Yellowstone	79,000 (5%)	27,513 (35%)
Upper Missouri	930,356 (14%)	254,303 (27%)
Marias	2,431,563 (53%)	979,905 (40%)
Middle Missouri	1,605,173 (19%)	740,138 (46%)
Musselshell	279,912 (5%)	67,562 (24%)
Milk	2,417,438 (29%)	526,937 (22%)
Lower Missouri	2,107,740 (46%)	832,592 (40%)
Lower Yellowstone	708,462 (22%)	85,117 (12%)
Lower Tongue	5,362 (8%)	590 (11%)
Beaver	149,330 (62%)	120,093 (80%)
	10,881,315 (18%)	3,667,225 (34%)

TABLE 24

WATER EROSION ON RANGELAND/PASTURE IN THE
STATEWIDE 208 STUDY AREA

BASIN	ACRES IN RANGELAND/PASTURE & % OF BASIN TOTAL	ACRES WITH SLIGHT-SEVERE EROSION & % OF BASIN LAND USE TOTAL
Kootenai	36,105 (71%)	0
Clark Fork	1,160,092 (14%)	185,966 (16%)
Jefferson	3,573,303 (69%)	1,069,670 (30%)
Madison	147,561 (59%)	120 (1%)
Upper Yellowstone	662,243 (41%)	62,130 (9%)
Upper Missouri	3,375,191 (51%)	531,341 (16%)
Marias	1,539,719 (33%)	456,702 (30%)
Middle Missouri	5,906,085 (69%)	1,101,868 (16%)
Musselshell	4,558,454 (80%)	775,547 (17%)
Milk	5,394,178 (65%)	259,683 (5%)
Lower Missouri	2,343,350 (51%)	257,284 (11%)
Lower Yellowstone	2,248,722 (70%)	152,719 (7%)
Lower Tongue	60,415 (90%)	604 (1%)
Beaver	81,788 (34%)	16,957 (21%)
	31,087,206 (51%)	4,870,591 (16%)

TABLE 25

WATER EROSION ON IRRIGATED CROPLAND IN THE STATEWIDE 208 STUDY AREA

BASIN	ACRES IN IRRIGATED CROPLAND & % OF BASIN TOTAL	ACRES WITH SLIGHT-SEVERE EROSION & % OF BASIN LAND USE TOTAL
Kootenai	4,570 (<1%)	40 (<1%)
Clark Fork	209,369 (3%)	28,249 (14%)
Jefferson	657,519 (11%)	9,691 (<2%)
Madison	4,400 (1%)	22 (<1%)
Upper Yellowstone	61,622 (4%)	4,580 (7%)
Upper Missouri	322,724 (5%)	42,410 (13%)
Marias	192,789 (4%)	27,492 (14%)
Middle Missouri	56,075 (<1%)	13,151 (23%)
Musselshell	110,850 (2%)	6,344 (6%)
Milk	114,702 (1%)	5,007 (4%)
Lower Missouri	30,940 (<1%)	1,303 (4%)
Lower Yellowstone	62,462 (2%)	6,099 (10%)
Lower Tongue	295 (<1%)	15 (5%)
Beaver	300 (<1%)	0
	1,828,617 (3%)	144,403 (8%)

TABLE 26

STREAMBANK EROSION IN THE STATEWIDE 208 STUDY AREA

	Cause of Erosion							
	Geologic	Modification	Construction (miles)	Logging	Grazing	Tillage	Mining	Other
Kootenai	2	0	120	0	7	17	0	0
Clark Fork	118	0	28	193	55	11	11	18
Jefferson	57	2	2	18	116	7	5	0
Madison	0	0	1	0	0	0	0	0
Upper Yellowstone	0	0	1	6	30	2	0	0
Upper Missouri	131	0	8	0	24	10	1	8
Marias	323	0	0	0	34	20	0	40
Middle Missouri	25	40	15	85	412	54	10	0
Musselshell	317	179	0	90	241	20	0	0
Milk	65	0	0	0	5	19	0	0
Lower Missouri	0	95	222	0	23	0	0	0
Lower Yellowstone	54	0	0	0	0	1	0	0
Lower Tongue	0	0	0	0	0	0	0	0
Beaver	0	0	0	0	0	0	0	0
	1092(32%)	316(9%)	397(12%)	392(12%)	947(28%)	161(5%)	27(<1%)	66(2%)

to be natural. Of the man-related activities considered to cause streambank erosion, grazing affected the most miles. Most of the grazing-impacted streams are expected to occur in smaller pastures located close to ranch headquarters and subjected to year-around use or are those used for concentrated winter feeding.

The 179 miles of stream modification in the Musselshell Basin are the result of past railroad grade construction. Flow fluctuation as the result of operations of the Fort Peck Reservoir account for the 95 miles of erosion in the Lower Missouri Basin. Excluding natural erosion, the Middle Missouri and Musselshell Basins had the greatest number of miles of eroded streambanks. The major land use in both basins is rangeland/pasture.

According to the Conservation District survey, grazing and tillage accounted for 1108 of the total miles affected by streambank erosion in the study area; that figure represents about seven percent of the state's total stream miles. This information must be considered to be fairly cursory as the Districts only reported the most obvious and critical problems. Additional District assessments will more accurately quantify the extent of streambank erosion.

Sediment-wind erosion--Table 27 shows basin summaries for the degree of wind erosion. A total of 1,994,351 acres in the Statewide 208 area are affected by accelerated wind erosion. Of the total acreage affected, dry cropland accounted for 92 percent; but, those acres represent only 17 percent of the total dry cropland acreage in the Statewide 208 area. Of the rangeland/pasture acreages affected by wind erosion, the Middle Missouri River Basin had the greatest number. Other basins, such as the Musselshell and Milk, have nearly as much acreage in rangeland and pasture but were reported to have relatively little wind erosion.

Cropland wind erosion is an age-old problem; however, its significance as a source of water pollution is debatable. Obviously, soil that is being moved by wind action is ultimately deposited either on land or in water, but District data do not quantify actual water quality impacts. At any rate, the potential for aeolian deposition of sediment into water systems in the Statewide 208 area exists when approximately two million acres are losing topsoil.

Nutrients--Another agriculture-related water quality problem is nutrient runoff from confined feeding operations. The Conservation District survey was restricted to facilities used for extended periods of time and from which surface runoff entered a stream. This definition excludes winter feeding operations. Table 28 lists the basin figures. Although these facilities represent a potential threat to surface water quality in the area, the degree of impact is unknown and needs quantification. In addition, winter feeding areas should be included in an inventory of animal waste pollution sources. In some areas winter feeding in drainages is common and is polluting streams.

Land conversion--Even though agriculture-related pollution needs more analysis to better quantify its extent, the fact is obvious that it does represent a significant potential water quality problem in the Statewide 208 area. Consequently, agriculture trends, and in particular, conversion

TABLE 27

WIND EROSION CONTRIBUTING TO SEDIMENT POLLUTION IN THE STATEWIDE 208 STUDY AREA

Basin	Acres of Wind Erosion & % of Basin Total		
	Rangeland/Pasture	Cropland	Other
Kootenai	0	0	3,000 (78%)
Clark Fork	2,969 (<1%)	1,658 (<1%)	6,224 (<1%)
Jefferson	8,300 (<1%)	20,970 (3%)	2,215 (2%)
Madison	0	250 (4%)	20 (59%)
Upper Yellowstone	0	1,200 (1%)	0
Upper Missouri	9,190 (<1%)	96,436 (10%)	1,770 (1%)
Marias	8,462 (<1%)	610,429 (25%)	36,312 (28%)
Middle Missouri	59,750 (1%)	157,723 (10%)	225 (<1%)
Musselshell	1,796 (<1%)	35,978 (13%)	1,600 (2%)
Milk	5,877 (<1%)	214,203 (9%)	200 (<1%)
Lower Missouri	20,020 (<1%)	644,633 (31%)	365 (<1%)
Lower Yellowstone	20 (<1%)	40,021 (6%)	35 (<1%)
Lower Tongue	0	0	0
Beaver	0	0	0
	116,384 (.2%)	1,826,001 (3%)	51,966 (.1%)

TABLE 28

ANIMAL CONFINEMENT FACILITIES WHICH CONTRIBUTE
SURFACE RUNOFF TO RECEIVING STREAMS IN THE STATEWIDE 208 AREA

Basin	Less than 300 animals	300 to 1,000 animals	1,000 or more animals
Kootenai	0	0	0
Clark Fork	63	0	0
Jefferson	16	4	1
Madison	0	0	0
Upper Yellowstone	1	1	0
Upper Missouri	9	1	0
Marias	6	3	1
Middle Missouri	5	0	1
Musselshell	5	8	1
Milk	19	4	3
Lower Missouri	2	4	0
Lower Yellowstone	9	11	5
Lower Tongue	0	0	0
Beaver	0	0	0
	135	36	12

of marginal rangeland to cropland, is of interest because these lands are generally most susceptible to erosion.

The Districts were asked to estimate acres of rangeland converted to cropland since 1972, (Table 29). They were also asked to indicate how much of the land was being converted by use of Best Management Practices, how much of the converted land was Class IV-VI (land requiring specific limitations if it is to be used successfully for cropland), how much of the new cropland was being irrigated, and the source of the irrigation water. Most of the conversion is occurring in those basins where cropping is already extensive, i.e., Middle and Lower Missouri, Marias, and Milk Basins.

The plow-under of grassland is of concern to water quality management in the Statewide 208 area for several reasons. First, about half of the converted land is characterized as Class IV-VI. Class IV lands "have very severe limitations that restrict the choice of plants and require very careful management or both." Class V lands "have limitations that restrict normal tillage, and the choice of plants that can be grown. Lands are nearly level but wet, and may be frequently subject to flooding or ponding." Class VI lands "have continuing limitations that cannot be corrected, such as (1) steep slopes that have high erosion hazard, (2) shallow rooting zone, (3) stoniness, (4) excessive wetness overflow, (5) low moisture storage capacity, (6) high salinity or alkalinity---" (Conservation Needs Inventory, 1970). Thus, these lands have an inherent ability to produce sediment-laden and/or saline runoff unless they are carefully managed. And, as the districts indicated, over half of the conversions are not using BMP's. In addition, when new cropland is plowed under, it is often in large blocks rather than strips, thus increasing the potential for wind erosion. And, irrigation of submarginal land facilitates leaching of salts to ground and surface waters.

Wheat prices have stimulated conversion in eastern Montana. SCS estimated 250,000 acres were converted between 1967 and 1973. Montana Crop and Livestock Reporting Service has collected data on the breakup in the past four years. Slightly more than one million acres have been converted in the state since July 1, 1974. The conversion peaked at 325,000 acres in 1975, and has been decreasing slightly. Continued conversion of acreage to marginal cropland underscores the need for creating an awareness of environmental capabilities and constraints if future water quality degradation is to be avoided.

Silviculture

About one quarter (23 million acres) of Montana is forested. Of the forested area, an estimated 14 million acres are considered to be commercial forest and as such, have the potential to contribute nonpoint source pollution during some forest practice activity. Ownership of these commercial forest lands is shown in Table 30.

State, private, and BLM lands--A total of 183 known, suspected, or anticipated water quality problem areas related to silviculture activities were identified in the Statewide 208 area. Due to the nature of nonpoint source pollution and lack of adequate stream monitoring systems, many reported problems were difficult or impossible to document. In many cases, sil-

TABLE 29

SUMMARY OF LAND USE CHANGE FROM RANGELAND
TO CROPLAND IN THE STATEWIDE 208 STUDY AREA SINCE 1972

	Acres Converted (% of rangeland)	BMP's Applied (%)	Class IV-VI Land (%)	Acres Irrigated (%)	Water Source (%)	
					Well	Stream
Kootenai	1,000 (3%)	50	60	10	0	100
Clark Fork	9,181 (<1%)	91	69	47	11	89
Jefferson	14,320 (<1%)	82	32	92	2	80
Madison	200 (<1%)	100	10	0	-	-
Upper Yellowstone	2,800(<1%)	100	57	64	0	100
Upper Missouri	36,145 (>1%)	67	34	35	36	64
Marias	96,640 (6%)	54	51	3	0	93
Middle Missouri	140,147 (2%)	47	46	1	2	96
Musselshell	56,753 (1%)	50	59	8	1	92
Milk	144,821 (3%)	65	26	3	0	100
Lower Missouri	86,683 (4%)	34	72	1	0	100
Lower Yellowstone	45,522 (2%)	25	73	2	0	71
Lower Tongue	3,000 (4%)	50	80	0	-	-
Beaver	1,200 (2%)	50	100	0	-	-
	639,412	51%	48%	7%	2%	90%

TABLE 30

OWNERSHIP OF COMMERCIAL FOREST LAND IN MONTANA

Landowner	Acres	% of Total
U. S. Forest Service	7,944,700	56.35
BLM	315,000	2.23
Misc. federal	53,000	0.38
Indian	620,000	4.4
State	421,000	2.99
City/County	4,700	0.03
Private		
Industrial	1,590,000	11.28
Individual	3,150,000	22.34
TOTAL	14,098,400	

viculture activities were one of several concurrent land uses in a particular watershed making it difficult to specifically quantify the effects of the timber-use activity. A major general problem is that of checkerboard ownership. In many basins, independent and simultaneous forest activities of several owners cause more disturbance than if those activities had been coordinated. Identified problem areas are shown in figure 15.

Those watersheds currently the most severely degraded as the result of forest activities include: Fisher River, Shields River, Fish Creek (tributary to Clark Fork River), Thompson River, Tobacco River, and the Smith River.

Four major drainage basins were found to have significant silviculture nonpoint source problems and are discussed below. In most cases, particularly in areas of checkerboard ownership, it was not possible to determine which forest ownership was responsible for the degradation.

1) Kootenai River Basin--This basin lies in the northwest corner of Montana. Approximately 2.3 million acres of the Kootenai Basin's 2.4 million acres are forested. About 53 percent of the forest is of commercial value. The USFS is the largest single landowner. Slope and soil conditions are the primary limiting factors in the basin. Glacial till and glaciofluvial and glaciolacustrine deposits occur in narrow valleys and steep slopes. Timber production is extensive on these soils which present a severe erosion hazard when mismanaged.

2) Clark Fork River Basin--The Clark Fork River is a tributary of the Columbia River and receives water from most of Montana west of the Continental Divide. In the upper portion of the basin much of the timberland is administered by the USFS. On non-USFS lands, agriculture, mining, and urbanization add to silviculture nonpoint source problems. The middle portion of the Clark Fork River Basin, from the mouth of the Blackfoot River to the Flathead River confluence, receives water from large forested areas. Again, the USFS is the major landowner. The lower portion of the Clark Fork River Basin begins at the mouth of the Flathead River and extends to the Idaho state line. USFS ownership dominates the basin except in the Thompson River drainage.

3) Missouri River Basin--Timber harvesting trends have been gradually changing in the upper Missouri River Basin. Initially, most harvesting occurred on USFS lands; however, private timber resources are currently supplying 75 percent of the production. Though USFS ownership dominates the middle Missouri River Basin, Burlington Northern, Champion, and several large ranch companies own significant portions. Some water quality impacts are minimized due to dry climatic conditions in the basin. On the other hand, others are aggravated due to slow regeneration rates on some sites. Commercial timber resources of the lower Missouri River Basin are primarily limited to the Musselshell and Judith River basins headwater areas.

4) Yellowstone River Basin--The upper Yellowstone River Basin lies in southcentral Montana and is the only segment of the basin within the Statewide 208 area. Most forested land is owned either by USFS or Burlington Northern along with significant small private holdings. There are also scattered BLM and state ownerships. Much of the private land was harvested ten years ago but some merchantable timber still remains in most drainages.

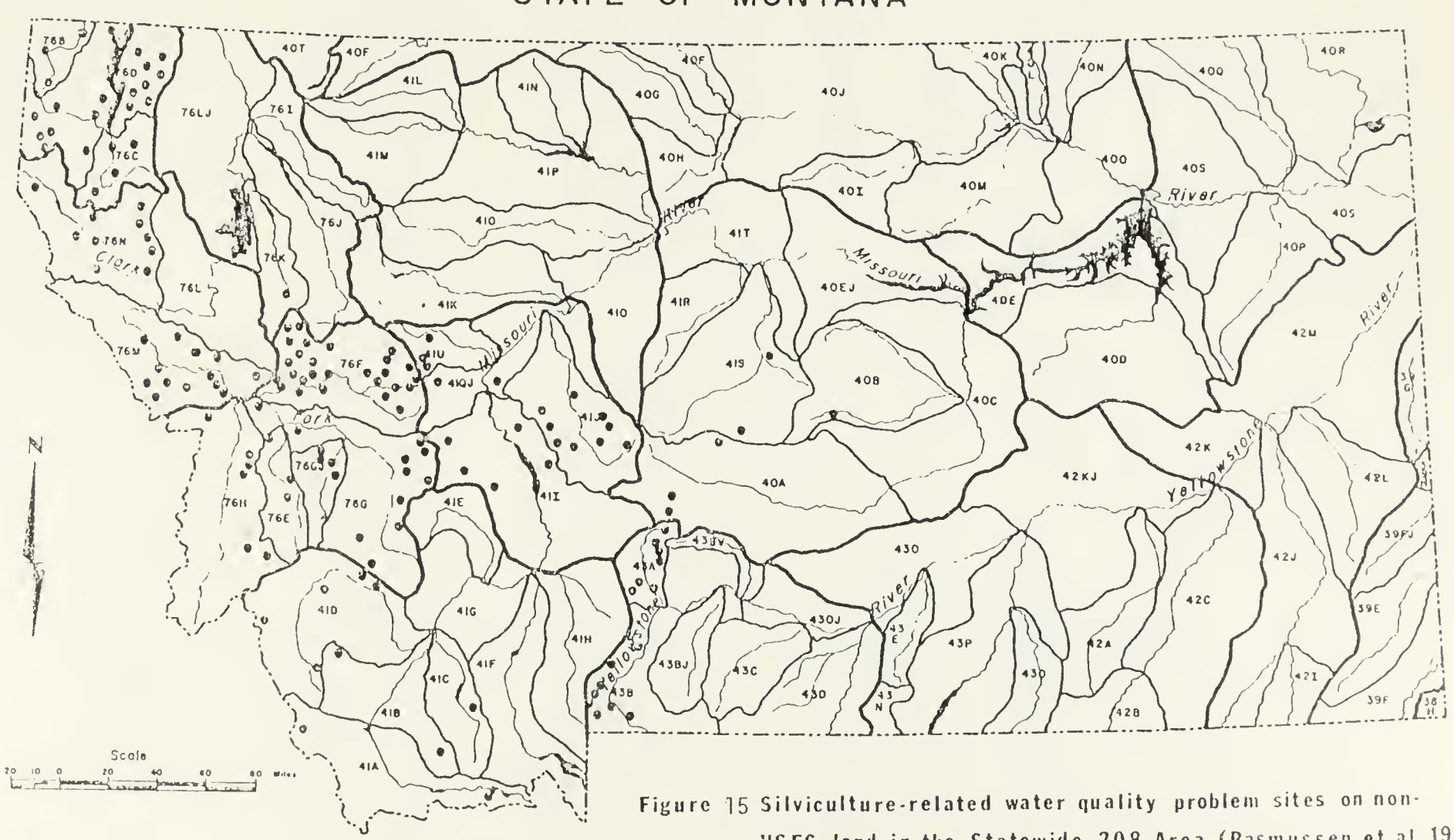


Figure 15 Silviculture-related water quality problem sites on non-USFS land in the Statewide 208 Area (Rasmussen, et al., 1978).

Several drainages have experienced extensive clear and selective cutting.

U.S. Forest Service Lands--National Forest boundaries in Montana encompass nearly 20,000,000 acres. The USFS has developed a sensitivity rating for each watershed within these National Forests. The ratings express susceptibility to erosion as a result of land use activities.

1) High sensitivity recognizes a high (80 percent) probability of accelerating erosion and of polluting the area's waters when following routine, normal management practices. Prevention of erosion in these areas will require extraordinary measures. In some situations, prevention may not be feasible under existing technology and knowledge.

2) Moderate sensitivity is the most commonly occurring sensitivity class. Accelerating erosion due to oversight or carelessness in carrying out routine management practices can occur, but adequate quality control should overcome most problems.

3) Low sensitivity lands present few constraints to management, or there is little probability (20 percent) of accelerating erosion when following routine management practices.

The sensitivity classification is intended to alert land use planners to possible erosion problem areas prior to project initiation. Finalized maps depicting the sensitivity classes are presently available.

The USFS has also identified water quality problem areas in Montana forests. Maps have been developed to depict these problem areas which are summarized by activity, severity, and feasibility for correction in Table 31. Table 31 also essentially summarizes management priorities on National Forest lands in Montana; roads, by virtue of impact severity and high feasibility for correction are the major management priority. As mentioned previously in the monitoring section, the USFS is preparing additional information on 208 assessment and implementation activities as required in the Water Quality Bureau/Forest Service Agreement.

Mining

The Statewide 208 assessment of mining-related water quality problems resulted in site specific identification of 133 problem areas. Although no more than 25 percent of the cited problems have supporting field data, some degree of water pollution could be documented at all sites. Mining-related water quality problems have occurred in nearly every major drainage basin in central and western Montana (Figure 16). The 133 problems can be grouped into five main categories:

Problem Type	Percentage
mine drainage	17
tailings and waste dump erosion	34
placer workings	35
sand and gravel mining	12
roads and ground disturbance	2

TABLE 31

AN EVALUATION OF POLLUTION IMPACTS ON MONTANA'S NATIONAL FORESTS

	SEVERITY OF IMPACT											
	HIGH				MODERATE				LOW			
	Feasibility of Correction			Total	Feasibility of Correction			Total	Feasibility of Correction			Total
Activity	High	Moderate	Low		High	Moderate	Low		High	Moderate	Low	
Roads	7	18	5	30	37	34	6	77	15	15	13	43
Timber Harvesting & Logging	2	7	5	14	24	17	7	48	23	13	3	39
Grazing & Stockwater	6	9	4	19	11	27	11	49	20	33	21	74
Municipal & Domestic	1			1	2			2		2		2
Recreation & Aesthetics			1	1	3	4	2	9	12	5	20	37
Mining		3	4	7	2	14	8	24	3	4	7	14
Total	16	37	19	72	79	96	34	209	73	73	64	210

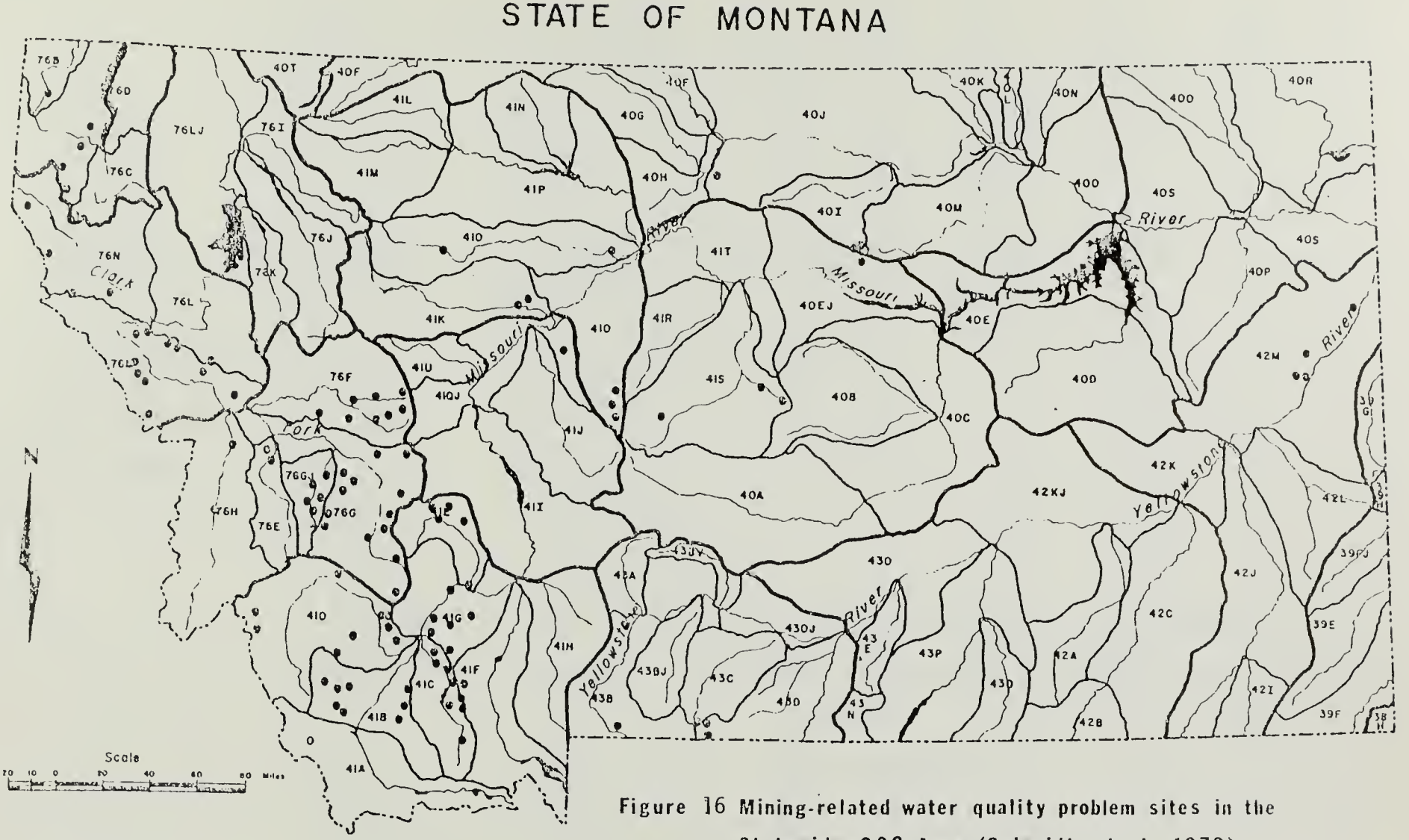


Figure 16 Mining-related water quality problem sites in the Statewide 208 Area (Schmidt, et al., 1978).

Of these 133 problems, 18 problems were identified as the most serious based on extent and severity of water quality impacts, length of affected streams, and extent of the mining area (Table 32). Of these major problems, 53 percent are caused principally by erosion of tailings and waste dumps, 35 percent are drainage related, and 18 percent are related to old placer workings.

Three major drainages in the Statewide 208 study area are experiencing the most significant levels of mining development. The upper Clark Fork River Basin has the most hard rock operating permits (7) in the state and the most identified mining-related problems, excluding placer mining. The basin contains the Anaconda Company's operations, the Black Pine Mine, and four limestone or silica mines. There are 141 small miner operations in Deer Lodge, Granite, Powell, and Silver Bow counties. Exploration activity in the basin is significant in both the Flint Creek Range and the Boulder Batholith area. Phosphate reserves are extensive around the Flint Creek Range and north of Garrison. Applications for oil and gas leasing have been received for most of the Flint Creek range.

The Beaverhead River drainage basin has five operating permits, all related to talc mining in the Ruby Range. Mineralization is high as is the potential for future development in the basin. Natural gas reserves are accessible in the Centennial Valley. Two drainages are affected by placer mining.

The Missouri River drainage, Holter Lake to Three Forks, has a number of quarry operations and several hard rock and placer mining related problems. Exploration for uranium, molybdenum, and silver is currently underway in the basin.

TABLE 32

SUMMARY OF MAJOR MINING RELATED WATER QUALITY PROBLEMS IN MONTANA STATEWIDE 208 AREA

Mine or District	Drainage	Mine Type	Problem	Problem Status
Little Ben Mine	King Creek/ Peoples Creek/ Milk River	Silver-Hardrock	Erosion of tailings and deposition into stream.	No work on problem known.
Bannack	Grasshopper Creek/ Beaverhead River	Gold Leaf Mill Gold Placer	Erosion of old mill tailings into stream. Old hydraulic mining banks eroding. Metals and sediments problem. Approx. 24 km of stream affected.	Preliminary investigation completed. Conceptual abatement plan developed.
Virginia City	Browns Gulch/ Barton Gulch/ Ruby River	Gold Placer	Erosion of disturbed placer areas. Deposits and sediment in stream.	No work on problem known.
Crystal Mine	Uncle Sam Gulch/ Cataract Creek/ Boulder River	Silver-Hardrock	Erosion and sediment transport from pits and wastes. Acid mine discharges. Sediment, metals and acid problem.	Technical investigation completed. Legal action being taken by DHES.
Comet Mine	High Ore Creek/ Boulder River	Silver-Hardrock	Erosion of old mill tailings. Some acid water production. Sediment and metals problem.	Preliminary investigation completed. No further action.
Hughesville District Block P Mine	Dry Fork/Belt Creek/Missouri River	Silver-Hardrock	Acid mine waters from old adits and waste dumps. Metals, sulfate, acid problems. Effects extend to Belt Creek.	Technical investigation completed. Corrective measures developed; corrective progress planned but not funded.
Neihart District	Carpenter Creek/ Belt Creek/Missouri River	Misc.-Hardrock	Acid mine drainage from mine workings and from waste rock dumps. Metals, acidity, sedimentation problem.	No work on problem known

TABLE 32 (continued)

Mine or District	Drainage	Mine Type	Problem	Problem Status
Sand Coulee Mining Area	Sand Coulee Creek/ Missouri River	Coal-Underground	Acid mine drainage from 9 old mines. Sediment, coating of stream bottom, metals, acid problems. Extends to Missouri River.	Technical investigation completed. Corrective measures outlined. No action on corrective plan.
Gould Mine	Gould Creek/ Fool Hen Creek/ Canyon Creek/ Little Prickly Pear Creek	Gold-Hardrock	Acid mine drainage; erosion of waste dump	No work on problem known
McLaren Mine New World District	Daisy Creek/Stillwater River	Gold-Hardrock	Precipitation infiltration into wastes and disturbed areas. Acid mine drainage, metals, sediment. Daisy Creek aquatic community depressed and devoid of fish for 1.8 miles downstream from mine.	Technical investigation completed. Corrective measures developed; corrective program planned but not funded.
Glengary Mine New World District	Fisher Creek/ Clark Fork of Yellowstone River	Gold-Hardrock	Infiltration of precipitation into mine workings. Acid mine drainage -- metals, sulfate.	Technical investigation completed. Corrective measures developed; corrective program planned but not funded.
Snowshoe Mine	Snowshoe Creek/ Kootenai River	Misc.-Hardrock	Drainage from tailings contains metals; toxic to fish.	No work problem known.
Heddleston District Mike Horse Mine	Blackfoot River	Silver, Copper, Lead, Zinc-Hardrock	Acid mine drainage from several mines but Mike Horse Mine is major problem; tailings dam burst and deposited sediment downstream.	Reconnaisance investigation completed. No further action.
Elk Creek Placers	Elk Creek/ Blackfoot River	Gold Placer	Erosion of disturbed area. Erosion and deposition into stream.	No work known on problem.

TABLE 32 (Concluded)

Mine or District	Drainage	Mine Type	Problem	Problem Status
Forest Rose Mine	Dunkleburg Creek/ Clark Fork River	Misc.- Hardrock	Acid mine drainage; erosion of tailings; culvert plugged - additional erosion will occur.	No work on problem known.
Butte Mining District	Silver Bow Creek/ Clark Fork River	Copper	Effluent from mining facilities and major pollutatn input from old tailings deposits in Silver Bow Creek. Sediment, metals, sulfate problem. Stream aquatic community depressed in Silver Bow Creek.	Major correction of problem by Anaconda Company contribution completed. Additional corrective actions being investigated for stream system.
	Gold Creek/ Clark Fork River	Gold Placer	Erosion of disturbed areas from stream diversions and mining.	No work on problem known
Philipsburg District	Flint Creek	Misc.- Hardrock	Mercury from gold recovering operations in stream. Tailings erosion; adit discharges. Sediment and metals problems.	No work on problem known

b. Flathead Drainage 208 Program

Most of the water quality data collected in the basin can be grouped into two categories: 1) that collected on larger streams and lakes, intended to delineate areawide trends and provide an overview evaluation and 2) that collected on smaller streams usually with the intent of reducing the variables involved and delineating cause-effect relationships between management and water quality impact. There is, in addition, a growing body of data applicable to the geomorphic condition of stream channels, which seems to correlate well with rates of sediment production, thereby providing an indirect and relative indicator of water quality.

Areawide Studies

One study which evaluated water quality of the large subdrainages was the "Water Quality Inventory and Management Plan", prepared by the Water Quality Bureau of the State Department of Health and Environmental Sciences. After discussing data on several major streams and lakes, the report concluded that water quality in the Flathead Drainage is generally good and should meet applicable standards. In it the mainstem and North Fork of the Flathead River were described as "low in organic content and mildly alkaline". It noted, however, that algal growths are approaching nuisance conditions in parts of Flathead Lake, and that these growths are resulting from discharges of phosphate in the Flathead Drainage. Most of these phosphates result from nonpoint sources of pollution, with silvicultural, agricultural and urban growth believed to be contributing . Phosphates were represented at increased levels in the South and North Forks of the Flathead River, where considerable amounts of roading and logging have recently occurred.

In 1972, pertinent to the Wild Rivers Study of the Flathead National Forest, Robert Delk, the Forest Hydrologist, submitted a report titled "Hydrology of the North, Middle and South Forks of the Flathead River". While attending predominantly to a summary of water quality data, his report noted the following:

(1) Water quality in the subject streams was generally good.

(2) The geology of the basin plus high spring peak flows result in a high rate of natural sediment production.

(3) Roading and timber harvesting contribute additional sediment.

Small Watershed Studies

Other studies have been concerned with small watersheds. Among them was a study of the water quality of the Logan Creek drainage, approximately 15 miles west-northwest of Kalispell, undertaken during 1975 by the Department of Health and Environmental Sciences on behalf of the Flathead National Forest. Surface water draining from portions of the watershed receiving different types

and intensities of use, were monitored for a variety of parameters. Though concluding that water quality in the drainage was "excellent", the document also noted the following:

(1) "Areas where considerable logging is taking place close to streams reflect an increase in suspended sediment loading".

(2) "These effects are mitigated by green belts of untouched timber between the logging operation and the stream".

(3) "...Water quality improves to essentially natural conditions three or four years following activity".

Another study entitled "Water Temperature Surveillance, Glacier View District, Flathead National Forest" by Dale Thacker, 1971, measured water temperatures above and below logging operations. The results indicated that abnormally high stream temperature fluctuations are caused by the removal of streamside vegetation attendant to logging.

Funded through the 208, a study describing "Chemical Analysis and the Water Quality Benchmark System, Flathead Drainage 208", completed in 1977, provides the most detailed and process-oriented study of small watershed quality yet assembled in the Flathead Drainage. During the year of the study's duration, monthly sampling and field evaluation of 19 stations on small watersheds was accomplished by the State Forest Hydrologist and Weber and Associates. Chemical analyses and final report preparation were accomplished through the U. S. Forest Service's Experiment Station at Moscow, Idaho, which, in turn, intends to use the data for regional water quality modeling. Sample stations were sited so as to bracket logging activities. As anticipated from the outset, limitations of time and funding restricted the conclusions which could be drawn. However, some of the important results can be paraphrased as follows:

(1) "Certain geologic formations produce a characteristic 'brand' of water quality".

(2) "Due to the presence of glacial till in their watersheds, some streams have a much higher potential for mobilizing sediment than others".

(3) "Nearly 50 percent of the water quality parameters exhibited dependence on stream discharge that could be accounted for by application of the dilution theory".

(4) "Though not described in a comprehensive sense in the text, water quality was generally found to be good, though somewhat degraded by logging in test watersheds."

A companion document produced by the Flathead Drainage 208 Project reported on water quality data collected between February and December, 1976, at ten new stations established in five small representative watersheds

located throughout the basin. These stations measured impacts from timber harvests in Beta, Blowout, Stoner, Wild Bill, and Valley Creek watersheds. Sediment was determined to cause the greatest impact on water quality, while increased temperature and nutrient levels also impacted existing quality. This study noted a seven-fold increase in total annual sediment yield downstream from logging operations. Areas with steep slopes underlain with glacial till material have the greatest potential for sediment yield. Table 33 summarizes the sediment yield data.

Some of the conclusions from this report are quoted below:

(1) "Viewed on an overall basis the data presented in this report suggest that a relatively small amount of nonpoint pollution is produced from forested watersheds within the Flathead Drainage. However, the landscape and hydrologic equilibrium of some watersheds has been extensively disrupted and the resulting nonpoint pollution arising from these watersheds ranges from a 10-fold to greater than a 100-fold increase relative to comparable undisturbed "baseline" watersheds."

(2) "Forest roads are an important source of nonpoint pollution in the Flathead Drainage basin. Within the study watershed inadequate provisions have been made for the control of storm flow discharges from the roading systems to the streams."

(3) "The results of this study suggest that the watersheds most sensitive to forest management practices are those characterized by steep slopes and underlain by glacial till. The data suggest that the natural variations in the chemical water quality of watersheds underlain by glacial till are sufficiently variable and/or undefined so as to preclude an accurate analysis of the overall chemical water quality impacts of timber harvest activities.

(4) "Although not isolated by the data collected, field observations suggest that in areas such as the Wild Bill watershed livestock grazing is responsible for an amount of nonpoint pollution production which is comparable to that amount produced by timber harvest activities."

Another study funded by the Flathead Drainage 208 Project involved the establishment of 46 sampling stations with samples generally collected semi-monthly for a one year period to measure impacts from agriculture. Results of the study indicated that agricultural practices have impacted several stream systems. Mission, Post, and Crow Creeks have the most polluted water in the drainage. Fecal coliform levels have been found to exceed state standards at 17 of the 23 sampling stations on these streams. Dissolved oxygen levels have exceeded state standards on 2 of the 13 stations on Crow Creek. Nutrient values (total inorganic nitrogen and total phosphorus) have exceeded the recommended instream limits for preventing nuisance algal growths on both Crow and Post Creeks. Extensive algal blooms have been observed on lower Crow Reservoir. More recent observations have revealed suspected sediment, bacteria, and nutrient loadings to several streams not previously sampled in the Little Bitterroot River drainage (Sullivan, Hot Springs, Garden, Dry Fork, Willis, and Boyer Creeks).

Table 33. Summary of annual sediment yield from monitored watersheds in the Flathead 208 area

Station[1]	Qs T/mi^2/yr	% of Qs Bedload	% Greater than upper station	% of Ap Roaded	% of Ap Logged	Total % Disturbed
0001	369.86	48.40	26,400	0.79	27.32	28.11
0002	1.67	5.71		2.20	36.60	38.80
0003	213.08	64.80	964*	2.50	69.10	71.60
0004	22.11	82.90		2.04	45.00	47.04
0005	28.94	10.70	488	0.50	1.43	1.96
0006	5.93	38.40		0.40	7.16	7.56
0007	174.84	2.20	431	0.55	26.50	27.05
0008	40.64	99.50		0.07	27.01	27.08
0009	7.34	47.40	521	0.40	18.32	18.72
0010	1.41	0.90		0.64	0	0.64

*Mamie Creek (0004) is a lateral control for Blowout Creek (0003)

[1]Location	I.D. Number
Lower Beta Ck.	0001
Upper Beta Ck.	0002
Blowout Ck.	0003
Mamie Ck.	0004
Lower Stoner Ck.	0005
Upper Stoner Ck.	0006
Lower Wild Bill Ck.	0007
Upper Wild Bill Ck.	0008
Lower Valley Ck.	0009
Upper Valley Ck.	0010

Additionally, excessive irrigation in the Whitefish and Stillwater drainages has caused soil saturation and stream bank slumping. Unrestricted livestock grazing along Ashley Creek has caused streambank deterioration, sedimentation, and excessive coliform concentrations. In addition, grazing along the Little Bitterroot has caused increased sedimentation in a naturally-ercsive area.

Groundwater

A Groundwater Study of the Flathead Drainage, undertook to outline: 1) the general geology of the region as it relates to the groundwater system, 2) the type and distribution of groundwater aquifers in the drainage, 3) the direction of groundwater movement in these aquifers, and 4) the areas within the drainage that are susceptible to water quality impacts generated by activities on the land surface.

Several conclusions can be drawn from the information presented in this report. Most significant is the fact that no apparent measurable change in groundwater quality in the drainage is evident over the 12-year period between 1964 and 1976. Although several aquifers are highly susceptible to contamination, only the groundwater in the perched dune sand aquifer is currently or has historically been found to contain widespread nitrate concentrations significantly in excess of the maximum permissible limit for drinking water. Groundwater discharge through the floodplain, outwash, and deep artesian aquifers is more than sufficient to dilute and flush out contaminants currently entering the system. In some cases, it is conceivable that future development could cause contamination but at what point in the development cycle is not known. Any future groundwater degradation will be a function of the type and concentration of surface development.

A site specific groundwater study was conducted near Kalispell to investigate the groundwater quality of Evergreen with the purpose of (1) documenting the existing groundwater quality in the Evergreen area, and (2) identifying any changes in groundwater quality that may have resulted from man's activities.

The groundwater system in the vicinity of Evergreen is representative of one type of shallow, unconfined aquifer that is present in many portions of the Flathead River Drainage. Evergreen was selected for a site specific water quality investigation because the groundwater aquifer at Evergreen is unconfined and therefore, potentially susceptible to groundwater contamination from individual septic tank systems in a high growth area adjacent to Kalispell, Montana.

Although this report found no measurable degradation of the groundwater, more recent investigations by Marc Spratt of the Flathead Drainage 208 Project have identified significant concentrations of fecal coliform and nitrate in the upper groundwater aquifer. This study concluded that the shallow aquifer may constitute a health hazard if used for domestic consumption.

SUMMARY

The body of water quality and correlative land capability data is growing in significant part through projects like the 208. While there is presently much more information needed in all aspects, particularly to delineate the water quality impacts of silviculture and logging, the situation as it now stands can be summarized as follows:

(1) Water quality in the drainage is quite good though variable and characterized by the geology of the subdrainages.

(2) The impacts of management are variable depending upon techniques used and the geomorphic-hydrodynamic properties of individual sites.

(3) Logging is presently degrading water quality though exact mechanisms and extent are difficult to establish due to the paucity of data. Some of the more important contributing elements appear to be:

a) sediment production due to road construction and the use of heavy equipment,

b) thermal pollution from cut-over areas, and

c) the liberation of phosphate due to leaching of disturbed soils.

(4) The impacts from agriculture are significant in certain identified stream segments with the major impacts due to irrigation return flows and improper grazing practices.

(5) Urban runoff from developed areas near Kalispell and Whitefish cause water quality violations for fecal coliform in receiving drainages (particularly Ashley Creek).

(6) Groundwater pollution is generally not a serious water quality problem in the basin, although evidence of contamination in certain shallow aquifers (Evergreen) has been documented.

c. Blue Ribbons 208 Program

This section contains results of the various Blue Ribbons studies and professional observations by members of the staff. The Blue Ribbons studies represent the most extensive water quality monitoring program conducted to date in the Gallatin and Madison Drainages (see figure 17); however, the short monitoring period will not reflect gradual trends. In assessing existing water quality with regard to the 1983 swimmable and fishable goals of the Clean Water Act, the following streams are the only ones in the Blue Ribbons planning area that fall short:

Stream Segment	Comments
1. Bozeman Creek below Kagy Boulevard	Unswimmable based on fecal coliform concentrations and other urban runoff pollutants.
2. East Gallatin River below Bozeman STP to Dry Creek Confluence	Unswimmable based on fecal coliform concentrations.
3. Godfrey Creek	Unswimmable based on fecal coliform concentrations.
4. Camp Creek	Unswimmable based on fecal coliform concentrations.
5. Elk Creek	Unswimmable based on fecal coliform concentrations.
6. Dry Creek	Unswimmable based on fecal coliform concentrations.
7. Cement Creek	No propagation of salmonoid fishes due to sediment.
8. Yellow Dog Creek east of Churchill	Observed animal contamination (no analyses).
9. Moore's Creek 2 miles north of Ennis to Ennis Lake	Observed animal contamination (no analyses).

Water Quality Assessment Summary

Gallatin River Mainstream

The character of the Gallatin River changes drastically from a pristine mountain stream as it flows out of the canyon south of Gallatin Gateway into a meandering river with increasing concentrations of solids and nutrients as it continues across the valley floor. In the canyon environment, suspended sediment is the only significant water quality pollutant observed. The suspended sediment loads result from 1) natural erosion, 2) logging and roading associated with timber harvesting, 3) construction, primarily the Big Sky development on the West Fork, and 4) combinations of the above.

FIGURE 17
BLUE RIBBONS "208" STUDY AREA

WATER QUALITY MONITORING STATIONS

On the valley floor, the first significant sources of nutrients, dissolved solids and bacterial contaminants flow from the Camp Creek Hills via Baker Creek into the river. These result from intensive agricultural activity and easily erodible soils. The East Gallatin River then contributes solids, nutrients and bacterial contaminants resulting from agricultural activities, construction, urban development and runoff and the Bozeman Sewage Treatment Plant effluent.

The mean sediment load in the Gallatin River increased from 20,000 to 538,000 kg/d (22 to 592 tons/day) between Yellowstone National Park and Logan. Nitrate concentrations were below the detection limit at Yellowstone National Park, but increased substantially to produce a load of 605 kg/d (1330 lbs/day) at Logan.

Portions of the mainstem of the Gallatin River may be completely dewatered during the irrigation season, as happened in 1977 during the course of this study.

Forested Tributaries of the Gallatin River

The overall condition of Squaw Creek water quality was good. No large scale movements of bedload were observed. Hell Roaring Creek remained clear throughout the study period. Swan and Portal Creeks were not included in any of the Blue Ribbons studies but appeared to carry only small sediment loads.

The West Fork of the Gallatin River carried very high suspended sediment loads in the spring. These are believed due primarily to easily eroded geologic formations, the Big Sky Development, and logging in the Yellow Mules.

Large amounts of sediment have been observed in the Buck Creek drainage during high flow. This is believed to result from the natural geologic instability and erodibility of the area.

The suspended sediment generated from the Taylor Fork watershed impacts the entire Gallatin River from the Taylor Fork confluence, downstream. The drainage integrates many natural conditions and man-caused impacts into a diverse water quality problem. Cement Creek, which is in the worst condition of all streams studied in forested drainages, is tributary to Taylor Fork. The very poor quality of Cement Creek is due totally to natural erosion. This small creek, which had a mean flow volume of only 0.3 c.f.s. during monitoring, produced enough sediment to cloud the entire Gallatin River below the Taylor Fork confluence. Other drainages in the Taylor Fork include Cache Creek and Wapiti Creek. Cache Creek has been disturbed by recent logging and roading in its upper drainage. The increase in suspended sediment and subsequent deposition on the channel bottom is very apparent when compared to lesser disturbed Wapiti Creek.

Sage Creek drainage, which is virtually undisturbed, carried high sediment loads due to its sedimentary geology.

The 1.0 mg/l limit set on iron concentrations was significantly exceeded in Cement Creek (5.08 and 9.63 mg/l), and exceeded in Upper Taylor Fork.

Non-forested Tributaries of the Gallatin River

The East Gallatin River is the most severely impacted stream in the agricultural study area. The sediment concentration in the East Gallatin has been increased by construction in the Bozeman area, urban runoff, realignment of Rocky Creek by highway construction, subsurface irrigation return flows, and most importantly by easily erodible soils in the East Gallatin River drainage. Camp Creek, a tributary to Baker Creek, is the second most severely impacted stream in the agricultural study area. The primary sources of sediment in the creek are the highly erosive soils in the drainage and changes, realignments and constrictions of the stream channel over the years. Godfrey Creek, a tributary of Camp Creek is heavily impacted by livestock concentrations at dairy operations.

Dry Creek, an agriculturally impacted tributary of the East Gallatin River is another significant sediment producer.

Rey Creek carried high concentrations of fluoride and arsenic. The fluoride concentrations measured were below limits set for drinking water, but the arsenic concentration exceeded limits.

Portions of Cottonwood and Hyalite Creeks were completely dewatered for irrigation purposes during the study. Camp and Bear Canyon Creeks were nearly dewatered. High fecal coliform counts were recorded in Dry, Camp, Godfrey and Bozeman Creeks and in the East Gallatin River.

Madison River Mainstem

The Madison River is impounded at Hebgen, Quake, and Ennis lakes. These bodies act as sediment traps and chemical equalization basins. When a tributary of the Gallatin, such as the Taylor Fork, produces a large sediment load, it may impact the entire Gallatin River below the confluence, but when a tributary of the Madison produces a large sediment load, that load will be largely settled out in the next downstream impoundment. Similarly, the total dissolved solids (TDS) in the Gallatin will increase with decreasing flow, but in the Madison, flow is regulated by Hebgen Dam and the flow volume will not be reflected in the TDS concentration.

The mean sediment load in the Madison River increased from 32,000 kg/d to 100,000 kg/d (35 tons/day to 110 tons/day) between Quake Lake and Three Forks. Nitrate concentrations were below the detection limit at Quake Lake, but increased downstream to produce a load of 85 kg/day (187 lbs/day) at Three Forks.

Arsenic and fluoride concentrations were found to be high in the mainstem of the Madison River. The public health standard for arsenic of 0.05 mg/l was exceeded at least once at each of the four Madison River stations. Since the arsenic concentration remains fairly constant or actually increases with the flow, it appears that sources along the river continue to add arsenic.

Algal growth along the Madison River mainstem interferes with recreational use and overall aesthetics. The potential for large algal blooms on Hebgen, Quake and Ennis lakes exists, as evidenced by the toxic bloom of Anabaena flos-aquae in the Grayling Arm of Hebgen Lake during the summer of 1977. That particular bloom was associated with the deaths of 30 cattle and 8 dogs, which drank water contaminated by the algae. Naturally high nutrient loads occur in the Madison River.

High water temperatures in the Madison River below Ennis Lake are the result of solar heating of the relatively shallow waters of the lake. Continued sediment buildup in the lake has resulted in an average depth of 9 feet with an average flow-through time of approximately 12 days. The high temperature conditions are destroying the "Blue Ribbon" trout fishery of the lower Madison.

Forested Tributaries of the Madison River

Cabin Creek, which is a tributary to the Madison River between Hebgen and Quake Lakes, was observed to carry tremendous sediment loads during spring snowmelt and intense rainstorms. The relatively undisturbed drainage is located in highly erosive geologic formations. The creek has been observed carrying enough suspended load to completely cloud the Madison River and Quake Lake; however, Quake Lake acts as a sediment trap and the river below it was not observed carrying heavy sediment loads during the study.

Beaver Creek, which is adjacent to Cabin Creek, carries heavy sediment loads principally due to snowmelt runoff in the erodible eastern portion of the watershed. Iron concentrations were also high in comparison to standards (0.93 mg/l compared to 1.0 mg/l). Timber Creek, a small tributary of Beaver Creek, carried iron concentrations in excess of the standards.

The West Fork of the Madison River contributes large sediment loads to the Madison River. The chief sediment source is believed to be the main channel itself rather than its tributaries. This is a result of past large scale surface erosion and deposition in the main channel. Standard Creek and Jack Creek appeared stable and did not carry noticeably high amounts of sediment during the studies.

Non-forested Tributaries of the Madison River

Elk Creek, an agriculturally impacted tributary of the Madison River, drains an area of highly erosive soils. The history of sediment production from Elk Creek is evidenced by a large "sand bar" immediately below its confluence into the Madison River. Other than during the spring runoff, the flow volume and the sediment load are insignificant to the Madison River. High fecal coliform counts were recorded in Elk Creek during the study. Cherry Creek also appears to be impacted by agriculture in its lower reaches and has been observed to carry large sediment loads. Both Elk and Cherry Creeks were almost completely dewatered for irrigation purposes during the course of this study.

Moor's Creek carries high concentrations of arsenic and fluoride. The arsenic concentrations measured did not exceed public health standards for drinking water, but the fluoride standard was significantly exceeded in one sample (6.68 mg/l).

Groundwater

Although there may be increases in dissolved solids in the study area, the only area of concern, from a water quality standpoint, is in the groundwater of the Gallatin Valley. Nitrate and total dissolved solids in the groundwater may be experiencing slight increases as reported in Groundwater Levels and Groundwater Chemistry, Gallatin Valley, Montana and Groundwater Pollution From Septic Tank Drainfields. Neither report predicts that problems will develop in the near future. The septic tank report does anticipate eventual problems from continued expansion of septic tank use in the area.

Nonpoint Source Assessment Summary

The primary nonpoint sources of pollution in the study area are agriculture, silviculture, construction, groundwater and hydrologic modification.

Agriculture

Erosion and sedimentation from cultivation, livestock concentrations, and streambank management are the main sources of sediment loads from agricultural operations in the study area. Confined livestock operations at certain points are contributing nutrients and fecal contamination to state waters.

Silviculture

Timber harvesting in easily erodible and unstable geologic formations has significantly increased sediment loads from certain drainages in the Blue Ribbons study area. Past management activities will likely continue to create problems for a number of years in the future.

Construction

Building and road construction sites throughout the study area, and particularly in the growing Bozeman urban area, are contributing sediment to streams. The Big Sky Development on the West Fork of the Gallatin appears to have produced significant construction related sediment loads.

Groundwater

Slight increases of total dissolved solids in groundwater near Bozeman over the past 25 years are believed attributable to increased leaching of dissolved solids resulting from increased use of irrigation water. The increases are believed to be of only academic interest at this time. Continued monitoring is recommended on a 10-year interval.

Nitrate concentrations in the upper levels of the groundwater immediately downstream from septic tank drainfields were found to be greater than natural concentrations. If development in the Bozeman area continues with one-acre lots and individual septic tanks, the currently accepted nitrate limit for drinking water may in time be exceeded in the upper levels of the groundwater. This could result in nitrate contamination of improperly cased wells.

Two of the four landfills in the study area (Ennis and West Yellowstone) are causing localized leaching of pollutant substances into the groundwater. Steps are being taken to correct these conditions. Leaching problems previously caused at the Logan landfill appear to have been corrected by restricting filling from a previously used drainage channel.

Hydrologic Modifications

Channel straightening to accommodate construction of transportation systems (roads and railroads), modifications by landowners, and constrictions caused by bridges and other construction, have significantly increased sediment loads. In some highly erosive drainages it is believed to be the main cause of erosion and has continued to be so 60 years after channel alteration. Impoundments on the Madison River (Hebgen, Quake and Ennis Lakes) are contributing to or causing two water quality problems at this time; algal blooms on Hebgen Lake and high water temperatures below Ennis Lake.

This section contains summaries of several technical studies performed by Blue Ribbons.

Forestry Study

Purpose and Description

The Forestry Study was initiated (a) to gain insights into the quality relationships of surface waters draining the forested lands of the Upper Gallatin and Madison River drainages and (b) to develop a comprehensive water quality data base for the forested sections of the Blue Ribbons Study Area. The study plan included as one of its objectives:

Monitor and perform laboratory analyses on water quality samples obtained at 27 stations. Each station was to be sampled 13 times over a 15 month period. These stations are illustrated in Figure 17. Values were obtained for streamflow, suspended sediment, and dissolved constituents.

Conclusions

Sediment was found to be the most significant water quality pollutant flowing from the forested watersheds. The easily weathered and more soluable geologic formations were observed to produce streamwater with high suspended and dissolved loads. The more resistant rock types produce streamwater with low suspended and dissolved loads. These trends were observed at both control (baseline) and disturbed (management impacted) stations.

Geologic formations were grouped into three general categories-basement rocks (resistant); volcanic intrusive rocks (resistant); and sedimentary rock, glacial deposits, and alluvium (easily weathered). Each of these geologic categories has a different potential for suspended and dissolved loads.

Agricultural Study

Purpose and Description

The Blue Ribbons Agricultural Study was designed to parallel the Blue Ribbons Forestry Study so that, when combined, the two studies would produce a comprehensive water quality data base for the entire study area. Additionally, the study was intended to identify and, and where possible, quantify pollutant loads from agricultural lands in the Gallatin and Madison drainages. Monitoring stations were located to give extensive coverage of the agricultural areas with an intensive look at suspected problem areas. The locations of all the agricultural study monitoring stations are displayed in Figure 17. Most stations were sampled 13 times between May, 1976 and July, 1977.

Conclusions

1) Flow Volume

a) Several stream segments were completely dewatered during the course of this study. They included Cottonwood Creek (AG26) during the sampling run of July 27, 1977, Hyalite Creek (AG15) following the last sampling run of July 27, 1977, and the Gallatin River below Irving Bridge, west from Belgrade, for a distance of approximately four miles on July 21, 1977. It is estimated that this section of the Gallatin River remained dry for five days.

b) Other stream segments which were almost completely dewatered during the course of the study are displayed below by location, station number and date.

Location	Station No.	Date(s)
Camp Creek at Interstate 90	AG03	May 25, 1977
Camp Creek near Churchill	AG04	June 29, 1977
Camp Creek at Highway 289	AG05	June 9, 1977 June 24, 1977 July 27, 1977
Hyalite (Middle) Creek near Four Corners	AG15	August 16, 1976 June 28, 1977 July 26,1977
Bear Canyon Creek near Mt. Ellis	AG14	March 23, 1977 July 26, 1977
Elk Creek near the mouth	AG21	June 27, 1977 July 25, 1977
Cherry Creek near the mouth	AG22	July 25, 1977

c) Flow volume in the Gallatin River decreases between Spanish Creek and the mouth of the East Gallatin River.

2) Dissolved Solids

a) All stream segments analyzed by this study are calcium-bicarbonate waters at high and low flow except for the following magnesium-bicarbonate waters: Bear Canyon Creek (AG14) at low flow; Dry Creek (AG01) at high flow; Camp Creek (AG03) at high flow; and the East Gallatin River (AG08) at high flow.

b) High concentrations of sodium and chloride are found in Camp Creek (AG03, AG04, and AG05), Godfrey Creek (AG06), and Rey Creek (AG28). Concentrations were somewhat independent of flow volume.

3) Sediment

a) The Gallatin River contributes over five times as much sediment to the Missouri River as does the Madison River. Seventy percent of the Gallatin River sediment load is produced on the main valley floor and primarily in the East Gallatin River drainage.

b) The sediment load in the Madison River is significantly reduced as it flows through Ennis Lake. Mean loading calculated from data generated by this report indicates a deposition of 26,000 Kg/day (29 tons/day) into the lake. These data are not flow weighted and sample collections were concentrated during periods of high flow. Therefore, 26,000 Kg/day is probably higher than the true daily average.

c) The sediment concentration averaged over all runs exceeded 100mg/1 at the following sampling stations; (for discussion purposes a sediment concentration in excess of 100 mg/1 may be considered high enough to impair propagation of fishes).

Location	Station No.	Mean Concentration
Camp Creek at IH 90	AG03	158 mg/1
Camp Creek near Churchill	AG04	208 mg/1
Godfrey Creek near Churchill	AG06	212 mg/1
Reese Creek near Springhill	AG07	133 mg/1
East Gallatin River near Manhatten	AG08	132 mg/1
Gallatin River at Logan	AG16	140 mg/1
Elk Creek at mouth	AG21	218 mg/1

4. Nutrients

a) Nitrate loadings in both the Madison and the Gallatin Rivers are low near Yellowstone National Park. Nitrate concentrations at the upstream stations were below detection limits for every sample.

b) The nitrate loading in the Gallatin River increased almost 800% between station AG24 at the Canyon mouth south of Gallatin Gateway, and station AG16 at Logan.

c) Phosphate loading in the Gallatin River decreases slightly as it flows from the Yellowstone National Park boundary (FS68) to the canyon mouth near Gallatin Gateway (AG24). It then increases 240% as it flows to Logan (AG16). Phosphate loading in the Madison River decreases 39% as it flows from below Quake Lake (FS73) to Varney Bridge (AG19). It then increases 210% as it flows to station AG20 near Three Forks. Summarizing, phosphate loading in the Gallatin River increases 230% between Yellowstone National Park and Logan. Phosphate loading in the Madison River increases 90%; however, due to dilution, the concentrations in both rivers are lower at the downstream end of the study area.

5) Microbiological Contaminants

The geometric mean of fecal coliform concentrations at the following stations exceed 400/100 ml and would appear to exceed the standards of the Montana Department of Health and Environmental Sciences for Stream Segments classified B-D_1 and B-D_2.

Location	Station	Fecal Coliform Geometric Mean/100 ml
Dry Creek above Edilou	AG02	413
Camp Creek at IH 90	AG03	591
Camp Creek near Churchill	AG04	846
Camp Creek at Mt. Hwy 289	AG05	559
Godfrey Creek near Churchill	AG06	4,467
East Gallatin River North of Belgrade	AG09	981
Bozeman Creek at Tamarack Street	AG11	457
Elk Creek at Madison River confluence	AG21	1,008

6) Trace Elements

The sampling runs of June 7-8 and July 26-27 included collections of acidified samples which were analyzed for lead, iron, zinc, copper, mercury, arsenic and fluoride.

Based on analyses of these samples, EPA drinking water standards for domestic water supplies were exceeded in the following streams for the elements listed:

Location	Station Number(s)	EPA Recommended Concentration Exceeded
Rey Creek	AG28	Fluoride, arsenic
Madison River	AG18, AG19, AG20	Fluoride, arsenic
Moore's Creek	AG23	Fluoride

Conclusions and Recommendations

1) The following stream segments in the agricultural study area which are currently classified Water Quality Limiting should be considered for reclassification to Effluent Limiting.

Segment	Justification
East Gallatin below outfall of Bozeman S.T.P.	Ammonia, dissolved oxygen sediment
Godfrey Creek (AG06)	Temperature, sediment
Bozeman Creek (AG11)	Sediment
Camp Creek (AG03, AG04)	Sediment
Rey Creek (AG28)	*Fluoride

*This recommendation is based on only two samples. Further study is warranted.

2) The following stream segments in the agricultural study area which are currently classified Effluent Limiting should be considered for reclassification to Water Quality Limiting.

Segment	Reason for Change
Elk Creek	Sediment
Moore's Creek	*Fluoride

*This recommendation is based on only two samples. Further study is warranted.

3) The following stream segments in the Blue Ribbons agricultural study area appear to contain fecal coliform concentrations in excess of state standards. Further efforts to control these problems should be a part of the continuing 208 program.

Segment	Station Number(s)	Suspected Source
Bozeman Creek below Kagy Blvd.	AG11	Urban runoff
Reese Creek	AG07	Agriculture - animal pollution
Camp Creek	AG03, AG04, AG05	Agriculture - animal pollution
Godfrey Creek	AG06	Agriculture - animal pollution
East Gallatin River	AG08, AG09, AG10	Urban runoff, Bozeman S.T.P.
Elk Creek	AG21	Agriculture - animal pollution, septic tank drainfield seepage.

4) The East Gallatin River drainage, Godfrey Creek, Camp Creek, Baker Creek and Reese Creek produce disproportionately large loadings of sediment and nutrients. A large sediment producer on the Madison River is Elk Creek. The continuing 208 program should determine if these problems can be corrected through additional plan implementation efforts.

5) Additional water quality studies will be needed to document changes which are expected as a result of rapid population increases in the study area. The most impacted drainage in the study area should continue to be the East Gallatin River.

Agricultural Inventory

Purpose

The source and extent of sedimentation in streams draining agricultural areas of the Gallatin Valley had never been comprehensively assessed. A cooperative program was established with the Gallatin Conservation District and Blue Ribbons to inventory sediment yields, determine whether the source was from adjacent lands or the confines of the channel, and determine suitable techniques for improving stream water quality.

Conclusion

A total of 465 square miles of watershed was inventoried as a part of this study (see Figure 18). Private land use was distributed as follows: Cropland - 37%, pasture/hayland - 8%, rangeland - 37%, woodlands - 24%, urban - 1%, and other - 3%. About 35% of the cropland inventoried needs improved residue management for erosion control. Stream channels appear to be the greatest sediment producer from private lands. Approximately 40% of the stream miles inventoried

FIGURE 18
BLUE RIBBONS "208"
STUDY AREA

WATERSHED INVENTORY
FOR SEDIMENT
PRODUCTION FROM
PRIVATE LANDS

were in fair to poor condition due to bank erosion. Channel alterations accounted for 25% of the affected channel length; 18% were attributed to agricultural activities and 56% were classified as a result of natural causes.

Sediment pollution from agricultural lands is not extensive; however, the report indicates need for improvement. The cost of implementing most corrective measures is not great and can be accomplished by better land management and proper planning.

d. Yellowstone Tongue 208 Program

General Overview

Water quality varies noticeably throughout the project area. Table 34 summarizes the water quality of the major streams.

Table 34

River	Salinity	Bacteria	Sediment	Oxygen demand
Yellowstone River	Low	Low	Moderate	Low
Tongue River	Moderate	Low	Moderate	Low
Powder River	High	Low	High	Low

Most of the water quality data used by the Yellowstone Tongue Areawide Planning Organization (YTAPO) was taken by the U.S. Geological Survey. Water quality measurements are common near the coal fields. However, outside the coal fields there are a number of drainages of 500 to 1,000 square miles with only a few water quality samples. Several smaller drainages have not been sampled.

Most of the streams in the project area carry a high sediment load and are rather saline compared to those located in other parts of the country. Bacteria levels are usually very low and the dissolved oxygen levels are usually well above the 5 parts per million level usually considered minimal for fish.

The Tongue and Yellowstone Rivers are considered to be fishable rivers. Most of the streams east of the Tongue River, including the Powder River, are not considered to be fishable. However, many people do fish them. Catfish of five to ten pounds are common in the Powder River and its tributaries.

Fishing, boating, and related recreational uses are common on the Yellowstone River but limited on the other rivers and streams. The Powder and Tongue Rivers and many of the smaller streams, including backwaters and drainage ditches, are utilized for informal recreation by the younger residents of the area.

With a few very noticeable exceptions adjacent to urbanized areas, the recreational use of the waters is not restricted by man-induced point source materials. Natural water quality factors which may be occasionally aggravated by man pose severe restrictions on the use of much of the water in the area. The high suspended sediment and dissolved solids loads, especially in the areas east of the Tongue River and north of the Yellowstone River, restrict use for recreational and agricultural purposes.

The bacteriological quality of the water of the major rivers is good. However, wastewater discharges to these rivers should be limited in order to maintain this existing high quality.

The physical and chemical quality of the waters and streams, with the exception of the Yellowstone and Tongue Rivers, is poor. Even though the wastewater discharged to these streams receives secondary treatment, the salinity, suspended sediment, and in some cases sodium levels are excessive. These materials are primarily the result of natural nonpoint sources which are not amendable to conventional control practices. The adoption of improved construction and farming techniques will help alleviate the problem. However, natural geological factors will continue to cause elevated salinity and sediment levels.

While not presently a significant problem, dewatering of streams and depletion of groundwater systems may have a major impact in the future. In surface water systems, dewatering aggravates the already marginal salinities and severely affects fisheries and the suitability of the water for irrigation. The Draft EIS on the Yellowstone River Basin published by the Department of Natural Resources and Conservation states, "However, even at the low projected level of development, the quality of the water (Powder River) would be unacceptable for irrigation at least one year out of two." In groundwater systems where there is limited recharge and slow water movement, dewatering is really the depletion of a natural resource.

Groundwater quality is quite variable throughout the project area. Generally, the area is characterized by high sodium, sulfate, and bicarbonate levels. A few of the deeper wells show excessive fluoride concentrations. Most of the groundwater is very soft and in some instances the sodium levels may be detrimental to human health. Sodium levels also limit the use of the water for irrigation. Selected groundwater quality samples are given in Table 35.

Detailed Water Quality Assessment

The following narrative provides a more detailed summary of the quality of the water in the project area. Information on some of the tributary streams in Wyoming has been included because it is difficult to evaluate a river system along political boundaries. The map in Figure 19 shows the location of the water quality sampling stations. The criteria against which measured values were compared are shown in Table 36.

Yellowstone River - Laurel to Sidney

This reach of the Yellowstone River has eight active water quality monitoring stations.

Turbidity

Turbidity had an average increase from 20 JTU's at Laurel to 117 JTU's at Sidney. The biggest jump (about 40 JTU's) occurred between Miles City and Terry. This increase can be attributed primarily to the Power River.

Suspended Solids

Suspended solids violated the proposed coal industry permits limit of 70 mg/l at all stations. Again, the largest increase (188 to 711 mg/l

TABLE 35

Selected Groundwater Quality Samples, With Data On The Tongue River Given For Comparison Purposes

	Depth feet	SAR	TOTAL DISSOLVED SOLIDS ppm	HARDNESS ppm	IRON ppm	FLOURIDE ppm	SULFATE ppm
Shallow, river bottom wells	25	3.1	934	470	6.0	.4	302
	18	5.8	1,710	646	-	.8	825
Fort Union Formation Wells	192	3.3	1,360	745	25.4	.5	413
	210	40	635	9	0	2.2	1.5
	140	21	4,090	610	.2	.4	2200
Hell Creek Formation Wells	850	20	762	44	.1	1.4	107
	371	65	780	5	0	2.2	16
Tongue River at Miles City		1.4	555	325	.05	.4	225

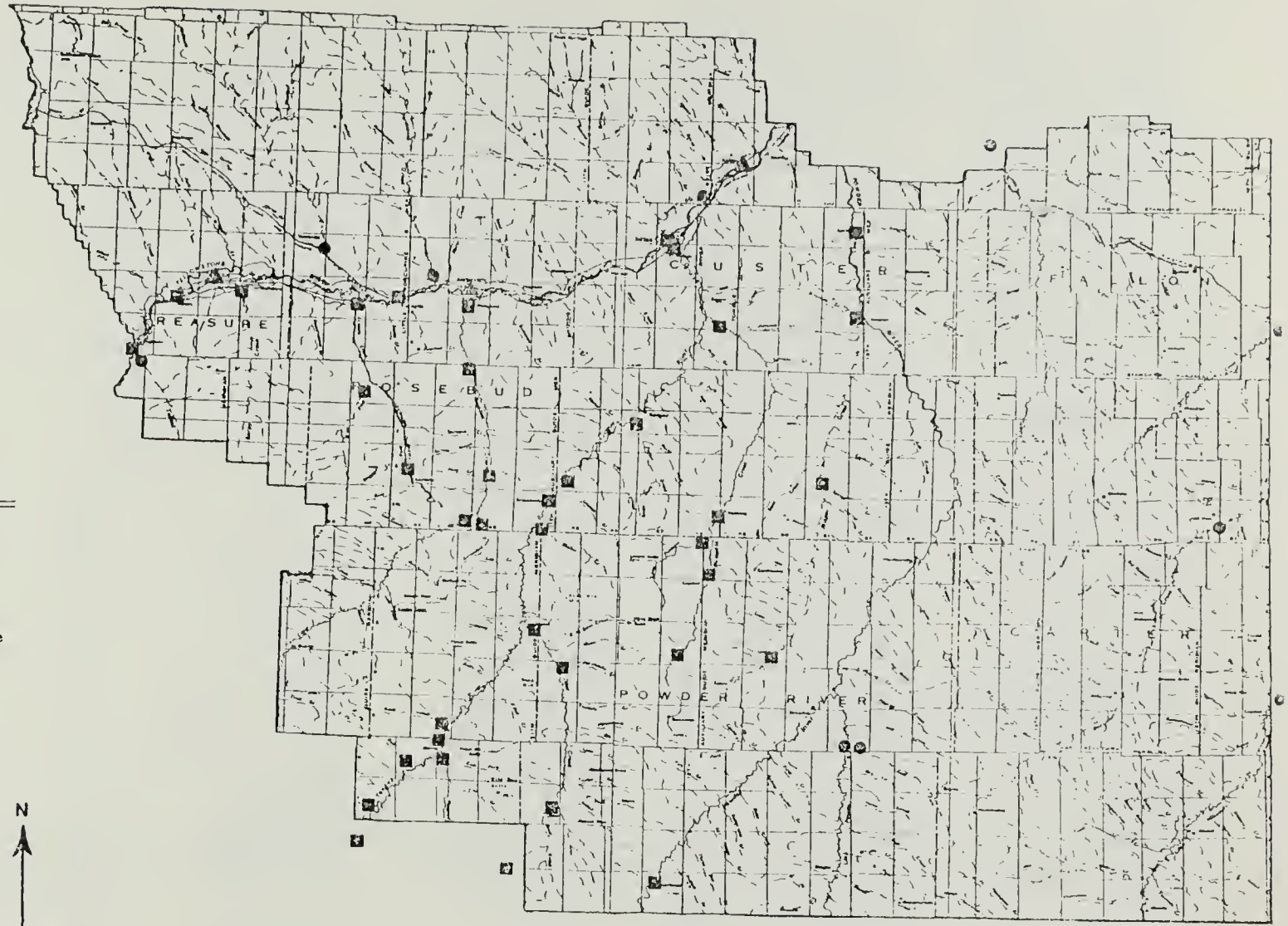
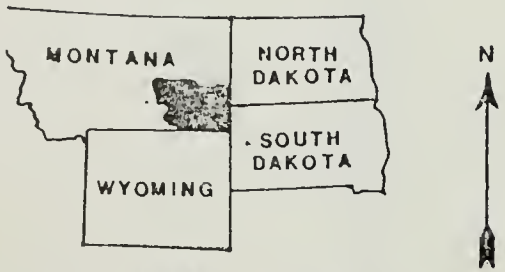


Figure 19

WATER QUALITY STATIONS

- USGS, monthly
- YTAPO/State
- Irrigation sampling site



N

scale:
one inch equals sixteen miles

YELLOWSTONE-TONGUE A.P.O.

Funded by an E.P.A. section 208 grant

Table 36 . Criteria used to evaluate the water quality data for the Yellowstone-Tongue 208 area.

Parameter	Criteria	Source
DO	5.0 and 7.0 mg/l	State Standard
pH	6.5 and 9.0	S.S.
Turbidity	10	S.S.
Total Suspended Solids	70 mg/l	Coal permit limit
Chloride	250 mg/l	WQC
Sulfate	250 mg/l	WQC
Flouride	1.4 and 2.4 mg/l	Drinking water
Total dissolved solids	500 mg/l	WQC
Total N	0.6 mg/l	Corvallis
NO_3-N	10 mg/l	WQC
Phos-Total	.05 mg/l	Corvallis
Fecal coliform	200 col/100 ml	WQC
Dissolved arsenic	50 ug/l	WQC
Total arsenic	50 ug/l	WQC
Dissolved barium	1000 ug/l	WQC
Dissolved Berylium	11 ug/l	WQC
Total berylium	11 ug/l	WQC
Dissolved boron	750 ug/l	WQC
Total boron	750 ug/l	WQC
Dissolved cadmium	10 ug/l	WQC
Total cadmium	10 ug/l	WQC
Dissolved chromium	50 ug/l	WQC
Total chromium	100 ug/l	WQC
Dissolved copper	50 ug/l	WQC
Total Copper	50 ug/l	WQC
Dissolved iron	300 ug/l	WQC
Total iron	1000 ug/l	WQC
Dissolved lead	50 ug/l	WQC
Total lead	100 ug/l	WQC
Dissolved manganese	50 ug/l	WQC
Dissoved zinc	50 ug/l	WQC
Total zinc	90 ug/l	WQC
Dissolved selenium	10 ug/l	WQC
Total selenium	10 ug/l	WQC
Dissolved silver	50 ug/l	WQC
Dissolved mercury	.05 ug/l	WQC
Total mercury	.05 ug/l	WQC

average) occurred between Miles City and Terry. It can be assumed that the Powder River is the largest contributor. From Terry to Sidney the suspended solids decreased from 711 to 372 mg/l.

Sulfate

Sulfate exceeded the criteria of 250 mg/l at five of the seven stations, increasing at an average rate of 33 mg/l at Laurel to 194 mg/l at Sidney. The largest increase (81 to 154 mg/l) occurred between Huntley and Meyers and can be attributed to the Bighorn River.

Total Dissolved Solids

Total dissolved solids (TDS) followed a similar pattern to that of sulfate, exceeding 500 mg/l at five of the stations and increasing from 174 mg/l at Laurel to 464 mg/l at Sidney, with the largest increase occurring between Huntley and Meyers (119 mg/l increase). This increase can be attributed to the Bighorn River.

Nutrients

Both total nitrogen and total phosphate exceeded the criteria at all stations, with the station near Terry recording the highest average for both elements (1.2 mg/l for nitrogen and 0.38 mg/l for phosphate).

Fecal Coliform

Fecal coliform samples were higher than standards at all stations, with Huntley having the highest average (2008 col/100ml). This may be attributed to the Billings sewage treatment plant which was being upgraded during this period.

Metals

The metals that exceeded the criteria were total copper, dissolved iron, total iron, dissolved manganese, total manganese, total zinc, dissolved mercury and total mercury. Only total iron seemed to show a general increase from Laurel to Sidney. Two high dissolved mercury values, 3.00 ug/l at Forsyth and 4.60 ug/l at Sidney, were observed. There are no known point sources for mercury.

Tributaries to the Yellowstone River Near Confluence

Between Laurel and Sidney there are seven tributaries to the Yellowstone that are sampled on a regular basis. The tributaries range from Fly Creek with a mean flow of 21 cfs to the Bighorn River (the largest tributary to the Yellowstone) which averaged 5319 cfs.

Turbidity

Turbidities ranged from an average of 20 JTU's at Armells Creek to 758 on the Powder River.

Suspended Solids

Suspended solids were collected at only two stations with 126 mg/l average on the Tongue River being the high value.

Sulfate

Sulfates varied from 241 mg/l average on the Tongue River to 1651 mg/l on Armells Creek.

Total Dissolved Solids

All stations exceeded the 500 mg/l criteria for TDS with Armells Creek having the highest average at 2832 mg/l.

Nutrients

The Powder River had the highest values for both Total Nitrogen and Phosphates at 2.2 mg/l and 0.67 mg/l resepctively.

Fecal Coliform

Fecal coliform is collected at only three stations with the Tongue River having the highest average at 221 col/100ml.

Metals

Total iron, manganese, zinc and mercury are the metals which violate the criteria most often. A high average of 49,257 ug/l total iron, 1008 ug/l manganese, and 251 ug/l zinc were all found on the Powder River. Mercury averaged 0.23 ug/l on Rosebud Creek.

Since the same parameters show very little change at Meyers, Forsyth and near Miles City on the Yellowstone, the tributaries Sarpy, Armells and Rosebud Creek appear to have little effect on the Yellowstone at this time. The Bighorn and Powder Rivers appear to have the largest effect on the Yellowstone River--the Bighorn, because of its large flow, and the Powder River, because of its high concentrations.

Powder River and its Tributaries

Ten stations, four of which are on the main stem of the Powder River, were examined for this report.

Turbidity

Turbidity on the main stem is high with the station at Arvada having the highest average (1665 JTU's). The station near Locate, the farthest downstream station, had an average of 758 JTU's. The tributaries generally

had low turbidity averages, except for the Salt Creek station which averaged 1400 JTU's.

Suspended Solids

Suspended solids were analyzed at only three stations with the station at Moorhead having the highest average (1456 mg/l).

Chlorides

Chlorides were above the criteria of 250 mg/l at only two stations--one on the Powder at Arvada (270 mg/l) and the other near Sussex on Salt Creek (1152 mg/l).

Sulfates

Sulfates exceeded the limit of 250 mg/l at all but one station with the highest average (1642 mg/l) near Kaycee on the South Fork Powder River.

Fluorides

Fluorides averaged 2.66 mg/l near Sussex on Salt Creek.

Total Dissolved Solids

Total dissolved solids were high at all stations except for the station at Ucross on Piney Creek (308 mg/l). The highest value on the Powder was 2006 mg/l at Arvada, while its tributary, Salt Creek, had the highest tributary average (4277 mg/l).

Nutrients

Nutrients were high at most stations. The station at Arvada on the Powder River had only one analysis for total nitrogen, however, that value was 21 mg/l, which is extremely high. The next downstream station (at Moorhead) had an average of 2.2 mg/l for 31 values for total nitrogen and a high of 8.8 mg/l. Total phosphates highest average was at the Moorhead station (0.52 mg/l).

Fecal Coliform

Fecal coliform exceeded the criteria of 200 col/100 ml. at most stations (but not by much) with the station on the Powder River at Arvada having the highest average (660).

Metals

Of the metals which violated the criteria, total iron, total manganese and total zinc had averages above the criteria at all Powder River stations at which they were analyzed. The highest average total iron and total zinc values (with more than one value) was at Moorhead (83,800 ug/l and

442 ug/1 respectively). The station near Locate had the highest manganese average (1000 ug/1). The EPA-funded station, South Fork Powder River near Kaycee, had the highest average violations of metals (iron - 135,958 ug/1, mercury - 0.4 ug/1, copper - 160 ug/1, chromium - 120 ug/1 and cadmium - 20 ug/1) of all the tributaries and main stem streams. However, the average flow was 11 cfs; therefore, the total loading may not be significant.

Tongue River and its Tributaries

Nine stations, seven of which are on the main stem of the Tongue River, were examined for this report.

Turbidity

The average turbidity ranged from four JTU's near Dayton to 181 JTU's at Miles City. The largest increase of 151 JTU's comes between stations at the Tongue below Brandenberg and the Tongue at Miles City.

Suspended Solids

Suspended solids increased from 43 mg/1 to 126 mg/1 between the Tongue below Brandenberg bridge and the Tongue at Miles City.

Sulfate

Sulfates had the biggest jump from 72 mg/1 to 179 mg/1 between the Tongue at Monarch and the Tongue at the State line.

Total Dissolved Solids

The largest increase of TDS (273 mg/1 to 469 mg/1) occurred between the Tongue at Monarch and the Tongue at the State line.

Nutrients

Nutrients had their biggest increase between the Tongue below Brandenberg and the Tongue at Miles City.

Fecal Coliform

Goose Creek below Sheridan had the highest concentration of fecal coliform with an average of 29,850 col/ml. This may be attributed to the Sheridan sewage treatment plant.

Metals

Total iron and total manganese had averages higher than the criteria at several stations with iron having an average value of 19,419 ug/1 on the Tongue at Miles City.

The supportive YTAPO report on water quality contains information from the results of several hundred water quality samples taken by the U. S. Geological Survey at 38 locations and by the state or the YTAPO at 11 locations. Data on irrigation return flows and on two special sampling runs down the Tongue and Powder Rivers are also included.

Violations of Criteria

The data indicate that the criteria listed in Table 36 have often been exceeded at the stations within the YTAPO area. The average measurement, as well as the maximum value measured, exceeds the criteria for many of the parameters and sampling sites listed. In a few cases, relatively high concentrations of pollutants were measured, but apparently some of this data was not accessible to the analysis program. This shows the monitoring stations are not intended to identify sources of pollution but form the base for detecting general changes in water quality. This information could be used to direct additional studies to help pinpoint the problem areas.

In spite of the large numbers of criteria violations indicated, the YTAPO does not know of a case in which the data from the sampling sites can be used to document man-induced pollution in a statistically valid method. There are several apparent sources of man-induced pollution including those documented by the special storm drain and irrigation return flow samples taken by the YTAPO showing elevated levels of man-induced pollutants. However, the data from the federal or state funded sampling sites cannot be used to show the effects of man-induced sediment or other pollutants.

As a result, the YTAPO has concluded that with the exceptions of localized problems, it is not possible to conclusively prove that the waters of the project area are not already in compliance with the 1983 goals of the Clean Water Act Amendments. Although by some standards the Powder River and many of the small tributaries to the Tongue and Yellowstone Rivers do not meet the goal of fishable and swimmable waters, the clause "... wherever attainable," provides adequate relief from the strict interpretation of the goals. It is apparent (but not documentable in a statistically valid fashion) that the quality of the waters, with the above mentioned exceptions, are as good or better than they were prior to the intrusion of the white settlers.

Classification of Streams

Due to the measured nonpoint source total dissolved solids loadings, all streams in the study area are considered to be water quality limited, including the Yellowstone River below the Bighorn River.

Nonpoint Sources

It is easiest to describe nonpoint source problems on a drainage basin-by-drainage basin basis instead of attempting to describe them on a source-by-source basis.

The TONGUE RIVER currently does not have severe nonpoint source problems. However, due to its relatively high water quality, the potential for future impact is high. The major anticipated problems are increased sediment loads due to construction or mining related activities near the river channel, and increased salinity levels due to the modification of groundwater recharge areas by mining and an increase in irrigation return flows.

The POWDER RIVER currently has high salinity and sediment loads caused by man-aggravated natural sources. The actual contribution due directly to man is reasonably small and difficult to isolate. The current sediment load of the Powder River is quite high. Thus, it may not be possible to measure any increased sediment load due to man's future activities. In fact, the construction of Moorhead reservoir or similar structure might reduce sediment transport. Part of this reduction in sediment transport would be due to trapping the upstream contribution of sediment. Part of it would be due to controlled flow levels which would reduce the potential for eroding and transporting sediment. The potential for elevated salinity levels in the Powder River is quite severe. Existing salinity levels make the water marginal for irrigation by normal definition even though it is being used relatively successfully by property owners adjacent to the river. Energy related development and/or the expansion of irrigation could cause salinity levels to rise to the point where crop yields would be adversely affected. The selective use of the better water in the tributary area, (Wyoming) and evaporative losses from reservoirs (such as the proposed Moorhead reservoir) would elevate salinity levels.

Similar problems could occur on smaller streams. Otter Creek near Ashland and Pumpkin Creek between Broadus and Miles City have a high potential for disruption by energy related activities.

A factor which may assist in controlling future water quality is that during normal critical low flow periods, most smaller tributaries are dry and, therefore, do not contribute high dissolved solids or sediment loads to the main rivers. Conversely, however, there is no contribution of higher grade dilution water.

Water Quality Problem Areas

The primary water quality problem in the YTAPO area is the high contribution of sediment and salts to streams due to natural conditions. Many people would not classify this as pollution.

There are several localized sources of man-induced pollution:

1) Household wastewater resulting from seepage from septic tank systems (or from the lack of septic tank systems) near urban areas. The four major problem areas have been or soon will be corrected -- Ashland, Rosebud, suburban Miles City, suburban Baker.

2) Partially treated human wastewater resulting from malfunctioning municipal wastewater treatment systems. The major problem areas, Forsyth and Ekalaka, are being corrected or brought up to tolerable standards.

3) Saline groundwater resulting from improper irrigation practices is a problem in many irrigated areas along the Yellowstone Valley. It is especially noticeable near Hysham and the east edge of Miles City. Corrective actions, including subsurface drainage, may result in the discharge of moderately saline water to surface drainages.

4) Irrigation return flows will provide a continuous source of moderately saline water and occasionally elevated levels of nutrients. Management practices can moderate but not eliminate these sources.

5) Storm water runoff from urban areas and industrial developments will increase in the future. Currently Miles City and Colstrip are the only areas with developed storm drains. Data from Miles City (included in a supportive report) indicates high fecal coliform levels in the storm water discharges.

6) Runoff from disturbed areas contributing high sediment loads during intense storm events.

Water quality problems will increase as the area becomes more developed. The types of problems anticipated in the future include those listed below. Due to the inability to predict the exact type and amount of development, it is not possible to provide a quantified predicition of future pollutants.

1) Salinity will increase due to irrigation expansion and to the movement of groundwater through mined areas before reaching the river.

2) The movement of groundwater through mined areas will also cause a change in the ratios between the various ions -- probably an increase in the proportion of magnesium.

3) The selective storage or diversion of the water from the higher quality tributaries of the Powder River in Wyoming would result in a major increase in the salinity of the Powder River in Montana.

4) The construction of additional coal conversion facilities (electrical generation or gasification) would involve disposal of large quantities of residual wastes -- primarily sludge of various types -- which could cause long term water quality problems through leaching.

e. Mid-Yellowstone 208 Program

The Mid-Yellowstone 208 undertook several special water quality studies to investigate suspected problem areas. These studies are briefly described in the following section.

Clarks Fork of the Yellowstone River

This study was undertaken to determine whether observable changes in water quality and associated biota in a stream could be related to agricultural land-use practices. Three reaches in the Clarks Fork of the Yellowstone River drainage were selected for monitoring, representing dryland farming, rangeland, and irrigation (see Figure 20). Streams sampled included the North Fork of Dry Creek (rangeland), the North Fork of Fivemile Creek (dryland farming), and the Clarks Fork Yellowstone River mainstem (irrigation). Sampling sites were established upstream and downstream of each stream reach.

During the April 25 through October 31, 1976 period, the sites were sampled as follows:

1) Ten to twelve times each for certain water quality parameters, including total suspended solids, specific conductance, fecal coliforms, ortho-phosphate, nitrate-nitrogen, turbidity, and temperature. Discharge was estimated where possible.

2) Three times each for benthic organisms including aquatic invertebrates and attached algae (periphyton).

3) Three times each for natural substrates (primarily rocks in the streams) with attached periphyton in order to estimate chlorophyll concentrations and thereby periphytic standing crop or biomass. This was done to obtain some insight into the level of primary production at each site.

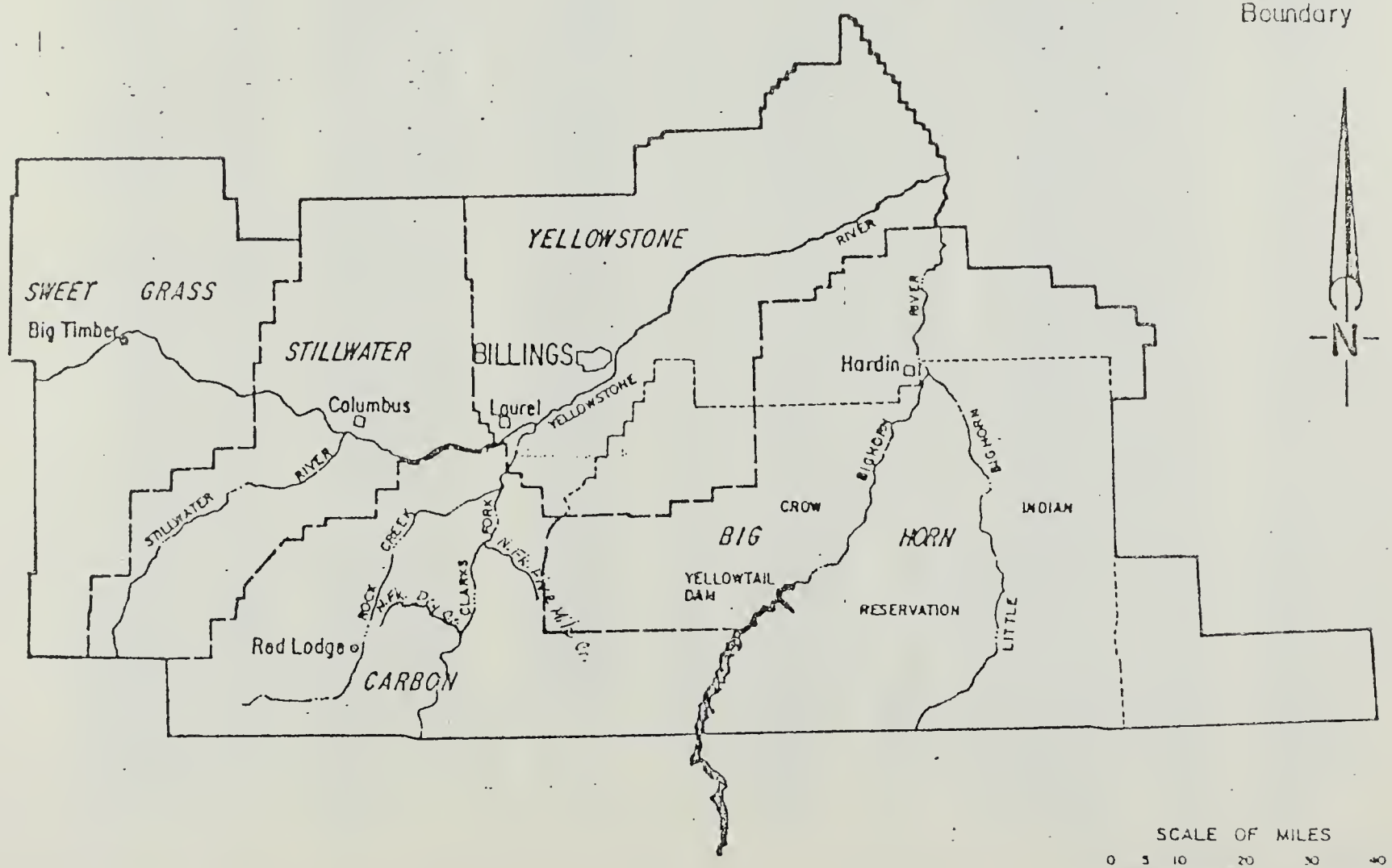
Conclusion

With the exception of the North Fork of Fivemile Creek, of the water quality parameters measured, changes in total suspended solids and turbidity were most significant. Downstream concentrations were several times higher in the North Fork of Dry Creek than at the upstream site. There was also a distinct downstream drop in periphyton biomass as measured by chlorophyll concentrations. Moreover, the benthic population was depressed downstream.

Total suspended solids, specific conductance, and water temperature increased slightly in the study reach of the Clarks Fork River. Very high concentrations of total suspended solids during the spring depressed the periphyton and benthic communities at both sites. Significant recovery occurred later in the year. Slightly higher periphyton levels downstream were suggestive of some nutrient enrichment, although nutrient measurements were inconclusive.

FIGURE 20

MIDDLE YELLOWSTONE 208 PLANNING AREA



Columbus Groundwater Study

A second investigation dealt with groundwater quality related to an industrial area near Columbus, Montana. One objective of this investigation was to define the extent and degree of groundwater degradation from the old sodium chromate waste pile at the Mouat Industries chrome ore processing facilities. The second objective was to determine the effect on groundwater quality of Timberweld's glue machine waste disposal practices. The item of primary interest was the effect of Timberweld's wash waste disposal pit on the quality of groundwater.

Conclusions and Recommendations

1) Groundwater in the study area is and will continue to be seriously degraded by sodium dichromate present in the soil profile at the site of the old Mouat operations.

2) The pollutant plume is gradually moving southeast of the site and will eventually reach the Yellowstone River. There was insufficient data to accurately estimate when the plume would reach the river.

3) The concentrations of chromium in most of the study area exceed the 0.05 mg/l drinking water standard. Therefore, groundwater in the area should not be used for domestic purposes.

4) The use of groundwater for stockwatering should be approached with caution. Groundwater with the high chromium concentrations should not be used for stockwater.

5) The contamination does not appear to presently degrade the Yellowstone River. However, should the pollutant plume continue migration in its present direction at the concentrations recorded in this study, the discharge of groundwater to the Yellowstone might eventually have a deleterious effect on aquatic life in the river.

6) It is estimated that from 10,000 to 17,000 years would be required for the dichromate at the old Mouat site to be removed by natural processes. It would take considerably more time for the groundwater and soil between the old chromate pile and the Yellowstone River to return to natural conditions.

7) A continuous groundwater and surface water monitoring program should be maintained on the dichromate problem.

8) It is concluded that the Timberweld waste pit was not degrading groundwater under the conditions present at the time of this study. It is recommended that a limited monitoring program be established to monitor phenol content in the groundwater in the study area if present disposal practices continue.

Duck Creek Area Groundwater Study

The objective of this study was to define the existing quality of groundwater in the terrace deposits north of the confluence of Duck Creek with the Yellowstone River approximately five miles southwest of Billings.

The original purpose of this investigation was to define the baseline quality of groundwater in the study area. It is anticipated that this area may one day be intensely developed for mobile home housing with septic tank drainfield systems for the disposal of wastewater. The Yellowstone County Sanitarian requested data to establish the existing quality of groundwater in the area before such development.

Because of limited funds, existing wells had to be used to obtain water quality data. Therefore, a baseline could not be established in the undeveloped part of the study area.

Big Timber Groundwater Study

The objective of this study was to determine the influence of the Big Timber Lagoon on the quality of local groundwater used for domestic purposes. The lagoon is located approximately 0.5 miles northeast of Big Timber, Montana, near the confluence of the Yellowstone and Boulder Rivers.

A total of six existing wells, eight new wells, and one spring were sampled twice during the study period.

Conclusions

1) The Big Timber Lagoon is leaking, and area groundwater in the terrace and Boulder River alluvial deposits is being slightly degraded.

2) The degradation does not pose a health hazard to individual wells and water systems in the vicinity of the lagoon under present conditions. Nitrate nitrogen concentrations were well within the 10 mg/l drinking water limit.

3) Movement of groundwater in the terrace and alluvial deposits is generally northeast and east from the lagoon towards the Boulder River. Limited sampling on the Boulder River did not show that the river was being adversely affected by groundwater flow from the lagoon.

f. Indian 208 Programs

The six Indian 208 programs were initiated on the following reservations: Blackfeet, Northern Cheyenne, Crow, Fort Belknap, Rocky Boy, and Fort Peck. These reservations are located on the map shown in Figure 21. The various Indian 208 programs are discussed in the following section.

(1) Blackfeet 208 Program

Beginning in 1978 the Blackfeet Tribe contracted with the U. S. Fish and Wildlife Service to develop a water quality management plan that would be consistent with the objectives of the Clean Water Act (Section 208) and responsive to local needs. The objectives of this effort were the following:

- To gather baseline water quality data from all of the major drainage areas of the Blackfeet Reservation, Montana

- To verify suspected sites of environmental degradation which lead to water quality deterioration

- To identify unknown sites of consequence which are resulting in water quality degradation

- To draft regulation standards to guide in alleviating present water quality problems and to assist in preventing future problems resulting from alleged poor land use practices.

Water quality sampling was conducted three to four times during 1979 at each of 21 stations for 17 parameters. The sampling station locations are described in Table 37.

The draft report indicated there were existing or potential problems in the following areas:

Streambed alteration - Little Badger Creek is adversely affected by stream channelization and other streams are affected by construction practices.

Stream dewatering - Irrigation use seriously dewaters Birch Creek, Two Medicine River, and Swiftcurrent Creek.

Forestry - Timber harvesting practices have caused problems with stream sedimentation and elevated water temperatures. An example of a serious problem in this regard is a clearcut area location on the east side of U.S. Highway 89 north of the St. Mary Ridge. This area has been burned and replanted unsuccessfully three times since 1967.

Oil drilling and mining - An example of adverse water quality impacts is in Cut Bank Creek, downstream from Glacier National Park.

FIGURE 21

INDIAN RESERVATIONS IN MONTANA

RESERVATION	LAND AREA (sq.miles)	POPULATION (BIA, '72)
Blackfeet	1485.4	6,216
Crow	2428.5	4,208
Flathead	1943.7	2,833
Fort Belknap	962.6	1,938
Fort Peck	1507.6	5,015
Northern Cheyenne	677.5	2,683
Rocky Boys	168.1	1,244

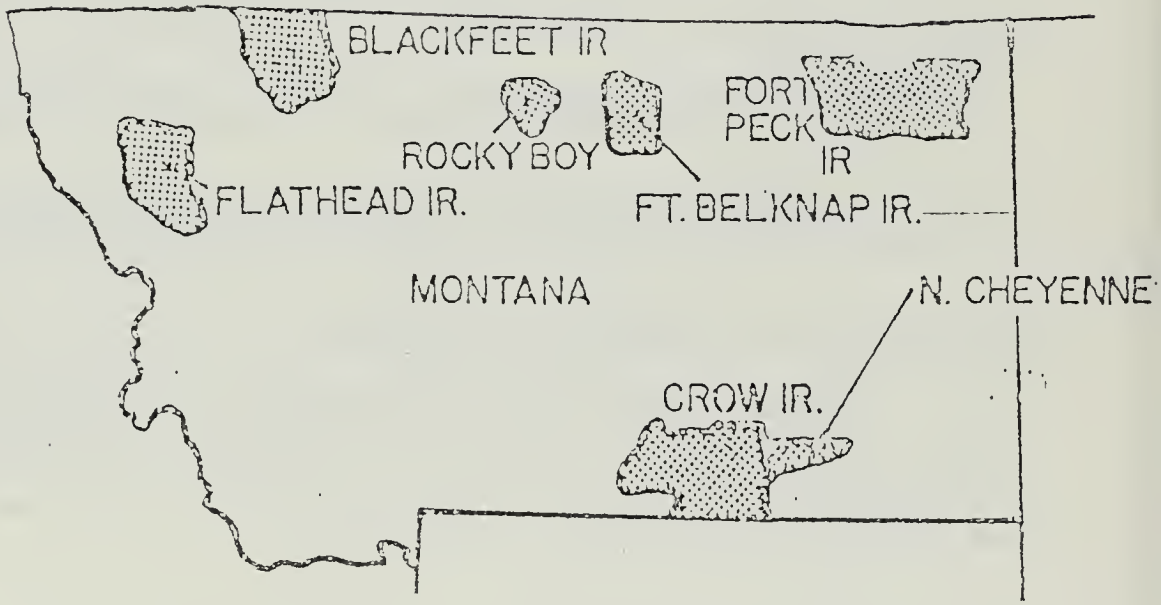


Table 37

Blackfeet 208 Water Quality Sampling Stations

Birch Cr. 1 (BC1) - The size of the creek at this point varies widely in relation to the amount of water being withdrawn for irrigation. It has a rock and pebble bottom with a wide channel, partially due to a flood several years ago.

Birch Cr. 2 (BC2) - Approximately 15 miles above BC1; bottom is rocky with some areas of solid shale. Some sediment along channel due to the cutting away of some dirt banks upstream. Fair sized stream, varies with irrigation needs.

Badger Cr. 1 (BG1) - Stream channel very wide due to flooding; rock, pebble bottom. At low flow, channel splits into many smaller ones. Flow varies according to irrigation needs, but not as much as BC1.

Badger Cr. 2 (BG2) - Approximately 18 miles above BG1. Rocks, pebble bottom, good flow. Good channel, stable banks.

Cut Bank Cr. 1 (CB1) - Grass-lined banks, some cutting action by stream. Silt, pebble bottom, good flow.

Cut Bank Cr. 2 (CB2) - Rock, pebble bottom, good flow. Trees and brush along bank, looks pretty stable.

Cut Bank Cr. 3 (CB3) - Rock, pebble bottom, good flow, deep run just above bridge. Brush along banks, fairly stable.

Divide Cr. 1 (DV1) - Pebble bottom, fair flow, approximately 10 feet wide, some brush along bank.

Divide Cr. 2 (DV2) - Rock, pebble bottom, fair flow, approximately 10 feet wide. Stream has been channelized. Bare, rocky banks.

Milk River 1 (MR1) - Rock, pebble, silt bottom. Good flow, channel very stable with brush and grass along banks.

Midvale Cr. 1 (MV1) - Rock, pebble bottom, some silt. Riffles and pools, fairly stable banks, some undercutting. Some flood damage. 10-15 feet wide.

Midvale Cr. 2 (MV2) - Rock, pebble bottom, some areas of solid shale. Some flood damage. 8-10 feet wide.

Swiftcurrent Cr. 1 (SC1) - Rock, pebble bottom, flow varies with releases from Sherburne Dam. Channel wide, bare, due to bridge construction.

Table 37 (continued)

Blackfeet 208 Water Quality Sampling Stations

Swiftcurrent Cr. 2 (SC2) - Rocky bottom, deep run at U.S.G.S. gauge house. Water level varies with releases from Sherburne Dam.

St. Mary River 1 (SM1) - Very good constant flow. Rock, pebble bottom, fairly good banks; some damage due to channelization for bridge construction.

St. Mary River 2 (SM2) - Very good, constant flow. Excellent banks; trees, brush. Mostly riffles and runs, rock, pebble bottom.

Two Medicine River 1 (TM1) - Rock, pebble, silt bottom; slow, deep run above bridge; fairly open banks. Flow varies in response to irrigation needs.

Two Medicine River 2 (TM2) - Rock, pebble bottom. Very open channel, little or no cover; some cutting away of banks. Flow varies with releases from Two Medicine reservoir.

Willow Cr. 1 (WL1) - Brush and grass along banks. Flow is quite slow. Pebble, silt bottom; fair amounts of aquatic growth.

Willow Cr. 2 (WL2) - Grassy banks, pebble, silt bottom; fair amount of aquatic growth. Sampled at end of road just above sewage lagoon outlet, the Browning, Montana city garage.

Willow Cr. 3 (WL3) - Sampled above road. Fairly small, very grassy banks. Rock, pebble bottom, a little silt, quite a bit of aquatic growth.

Livestock - Grazing and confined feeding operations pose a potential for fecal coliform contamination of some streams on the reservation.

Domestic wastewater - Browning and East Glacier have previously discharged polluted effluent, but planning is now underway to remedy these problems. The East Glacier Lodge was also identified as a source of elevated fecal coliform concentrations in Midvale Creek.

Pesticides and fertilizers - No adverse affects were noted, but problems may exist in areas of intense irrigation and agricultural use.

Conclusions and Recommendations

The draft 208 report recommended the following set of potential management controls:

Establishment of a stream classification system.

Permits for stream and lakeshore alterations, especially any work which might obstruct fish passage.

More restrictive logging, oil drilling, and mining practices, especially to minimize erosion.

Special guidelines for location of intensive livestock use areas and individual septic or holding tank systems.

Further study of the municipal wastewater treatment problems at Browning and East Glacier.

(2) Northern Cheyenne 208 Program

The Northern Cheyenne 208 Water Quality Management Report was completed and submitted to the Yellowstone Tongue Areawide Planning Organization (YTAPO) on September 26, 1977. The report documented the most important water quality problems and made recommendations for improvement of water resources on the 447,000 acre Northern Cheyenne Reservation in southeastern Montana. The Northern Cheyenne 208 study was financed by the U.S. EPA through a sub-contract from the YTAPO.

The Northern Cheyenne 208 Report covered potential water pollution problems from local sewage lagoons, in small recreational and livestock ponds, from certain soil types in the event of strip mining, from rural housing development and other land uses on the reservation. The report also indicated that the major threat to water quality was from nearby and upstream coal strip mining, energy conversion facilities and new agricultural irrigation in the Tongue River and Rosebud Creek drainages. These surface water supplies are the most available and best quality water sources for future agricultural or other uses on the reservation. In spite of a number of extensive energy impact studies, no one is yet able to quantitatively project the cumulative water quality impacts of

proposed energy and agricultural developments. Protection of local groundwater supplies from mining on or near the reservation is also of great concern.

The Northern Cheyenne 208 Report (Phase I) suggests various recommendations for water quality improvement or protection. A Phase II program was initiated in 1978 for implementation of those recommendations and for additional planning and studies as needed for water quality management.

The areas of study included: point source sewage lagoon facilities, ponds and small reservoir water quality, mined land reclamation and water quality, community and land use planning for water quality, and hydrologic and water quality data analyses. One of the significant outputs of these studies was a tribal water code which was adopted by Tribal Council Resolution on February 19, 1979. The code provides for a permit system to minimize adverse water quality impacts to reservation surface and ground waters.

Additional recent studies have focused on development of a suspended sediment predictive model for the Tongue River, organization and publication of the water data base for the reservation collected from 1975 - 1980, and surface water/ground water quality relationships in the Powder River Basin. A brief summary of these studies is presented below.

Sediment Study - Tongue River

One of the lesser understood natural hydrologic processes is that of sediment movement in western alluvial rivers. Yet coal mining companies, landowners and government agencies are increasingly put in the position of evaluating the potential impacts of strip mining operations on sediment loads in rivers without adequate knowledge of natural conditions. Such is the case with the Tongue River in southeastern Montana. In an attempt to rectify this, the Northern Cheyenne Research Project performed a study of suspended sediment and bedload trends in the Tongue River from Wyoming to Miles City. The field work was supported by Montco, a coal mining company located in Billings, Montana. Data analyses and model development was supported by Montco and EPA sources. The work analyzed existing suspended sediment data from 1975 to 1978 for the daily station at Brandeberg and monthly stations at the Stateline, Tongue River Dam, below Hanging Woman Creek and near Miles City. In October, 1977, the Miles City station became daily suspended sediment sampling station.

The results demonstrate the importance that geologic controls exert on rates of sediment production from upland areas. The sediment yield from the fine grained Lebo Shale and Tullock Members of the Fort Union Formation is several times greater than it is from the more resistant Tongue River Member. Up to 80-90 percent of the sediment load below the Tongue River Dam is moved within a six to eight week period during the annual river peak, usually May, June and July. About 90 percent of the sediment is derived from channel sources above Brandenberg. Below Brandenberg, sediment derived from local runoff increases from 10 percent to approximately one-third of the total load at Miles City.

The Tongue River Reservoir plays an important role by trapping all of the bedload of the river. The clear water releases below the reservoir then scour finer bed material leaving the armoured streambed condition that presently exists.

The sediment report provides the basis for understanding existing sediment trends in Tongue River Basin and predicting the potential impacts of any mining derived sediment.

Water Data Base

NCRP 208 staff assisted in the coding and production of a hydrologic data report giving virtually all surface and ground water data collected since 1975. The report will be published by EPA, Cincinnati. EPA 208 monies assisted purchase of the computer softwater necessary to automate the hydrologic and water quality data base. This report will nicely compliment the recent data report published by Montana Bureau of Mines and Geology and USGS covering hydrologic data in this region.

Surface Water/Ground Water Quality

Work on flow systems and water quality relationships is continuing. Three sampling runs were conducted on the Tongue River in October, 1979 during which the average ground water seepage rate was found to be 0.43 ft^3/sec per river mile. Field electrical conductivity increased by 57 umhos/cm and total dissolved solids increased by 24 mg/l between stations TR2 and TR1.

Water quality data collected in 1979 on small streams and springs was plotted and initial hypotheses on geologic-water quality relationships developed. The relationship of ground water/surface water flow systems and water quality to the various coal, clinker, sandstone, and shale lithologies is a fruitful area for further study.

Other Work

Contact has been made with the U.S. Fish and Wildlife Service in Hardin, Montana to consider initiating some fisheries related work on the reservation in FY 1980. Pond and spring head fencing and a bibliography summary of fisheries research on the Tongue River and Rosebud Creek drainages were the principal activities suggested. The upper reaches of Rosebud Creek, Lame Deer and Muddy Creeks could be investigated for fisheries potential. Mr. Carroll Barber, BIA Range Conservationist, was also contacted to assist in pond quality improvement.

A hydrologic balance study of Tongue River along the reservation was conducted for Montco and the results presented in a report for their mine permit application. The report addresses surface water and ground water inputs and outputs between Birney and Ashland during the 1979 water year.

3 (3) Crow 208 Program

The Crow reservation was included in the Mid-Yellowstone 208 planning area in 1976 and a separate portion of the Mid-Yellowstone grant ($200,000) was provided for special studies on the reservation. The water quality monitoring portion of those studies was conducted by HKM consultants and is briefly summarized below.

The 208 sampling program consisted of three phases of work. These included: reconnaissance; sampling and analysis; and analysis of data. All work accomplished in the reconnaissance phase was in construction and establishment of the sampling sites. Sampling site location are summarized in Table 38 and delineated in Figure 22. The second phase (sampling and analysis) of the program was initiated on June 28, 1976 and completed July 8, 1977. A total of seven sampling runs was undertaken for the 208 program. It was originally intended to sample mainly on a hydrologic event basis. However, the first six months of the program were marked by no significant runoff occurrence. This may have been somewhat fortunate since the first six months data was found to be useless due to poor laboratory performance. The third phase consisted of the analysis of data obtained in the sampling portion of the program and preparation of a water quality report.

A limited biological water quality study of the Bighorn and Little Bighorn Rivers and Pryor Creek was performed by Mayo Laboratories of Billings. The field work was performed during the June through July 1977 period. Sampling site locations and type of data collected are summarized in Table 38a. The study intent was to obtain basic biological data on each study unit for use in characterizing each stream for future, more extensive investigations.

Results from the water quality monitoring program are summarized below according to major drainage basins on the reservation.

Pryor Creek Basin

General Setting

The great majority of the Pryor Creek drainage basin is within the boundaries of the Crow Indian reservation. This stream has its headwaters in the Pryor Mountains in the southwest corner of the reservation and flows generally north to its confluence with the Yellowstone River near Huntley, Montana. Pryor Creek has three major tributary drainages. These are, in downstream order, Hay Creek, East Fork Pryor Creek and East Fork Creek. The mainstem of Pryor Creek, Hay Creek, and East Fork Pryor Creek all originate in the Pryor Mountains at elevations in excess of 7,000 feet. East Fork Creek, however, has its headwaters on the low divide between the Pryor Creek and Bighorn river drainages with maximum elevations of 4,500 feet.

Summary and Conclusions

The sampling site located on Pryor Creek at the boundary of the Crow Indian reservation summarizes the conditions of the entire watershed. Pryor Creek, as it passes through the reservation, increases hardness and changes from calcium bicarbonate type water at Pryor Gap to a mixed type at the reservation boundary consisting mainly of calcium, magnesium, sodium, sulfate and bicarbonate. Waters of Pryor Creek meet the requirements of the new Primary Drinking Water Regulations of the EPA throughout the reservation and, in general, is acceptable for domestic use and consumption. However, as Pryor Creek flows through the reservation, concentrations of several constituents increase to the point that while the water may be acceptable from a health standpoint, it may be less acceptable to a consumer for aesthetic or other reasons. Total dissolved solids, sulfate, iron and manganese are all constituents that equal or exceed the recommended levels of the Secondary Drinking Water Regulations. In general, the above constituents do not equal or exceed

Table 38

SUMMARY OF CROW 208 STREAM SAMPLING SITES

Station Name	Location	Data Type				
		Flow	Common Ions	Metals	Nutrients	Suspended Sediment
Pryor Creek above Pryor Gap near Pryor, Montana	NW¼ Sec 8, T6S, R26E	x	x	x	x	x
Pryor Creek at Pryor Montana	NE¼NW¼NW¼ Sec 5, T5S, R26E	x A/	x	x	x	x
Hay Creek at mouth near Pryor, Montana	SW¼ Sec 6, T4S, R27E	x	x	x	x	x
East Fork Pryor Creek at mouth near Pryor, Montana	SW¼ Sec 32 T3S, R27E	x	x	x	x	x
East Fork Creek near Billings, Montana	SE¼ Sec 30, T1S, R28E	x	x	x	x	x
Pryor Creek below Reservation boundary near Billings, Montana	N½NW¼ Sec 31, T1N, R28E	x	x	x	x	x
Bighorn River near St. Xavier	NW¼NE¼ Sec 16, T6S, R31E	x A/	x A/		x A/	x
Soap Creek above oil field near Fort Smith, Montana	SW¼ Sec 35, T6S, R32E	x	x	x	x	x
Soap Creek near St. Xavier, Montana	NE¼ Sec 10, T6S, R32E	x	x	x	x	x
Soap Creek at mouth near St. Xavier	Sec 17, T5S, R32E	x	x	x	x	x
Rotten Grass Creek above Ash Coulee near St. Xavier, Montana	Sec 24, T7S, R33E	x	x	x	x	x
Rotten Grass Creek near St. Xavier, Montana	NE¼ Sec 7, T5S, R33E	x	x	x	x	x

Table 38

SUMMARY OF CROW 208 STREAM SAMPLING SITES
(continued)

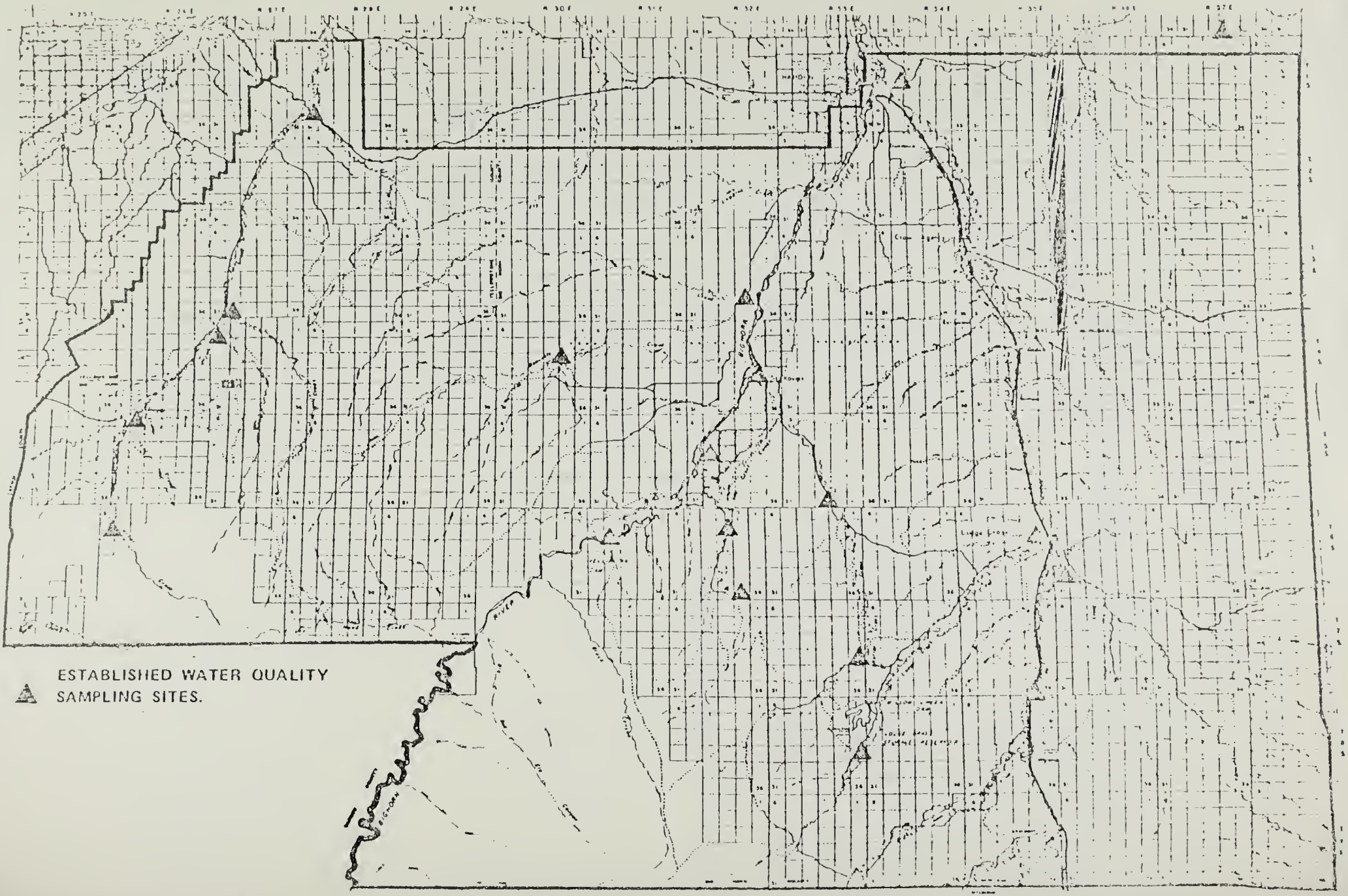
Station Name	Location	Data Type				
		Flow	Common Ions	Metals	Nutrients	Suspended Sediment
Rotten Grass Creek at mouth at St. Xavier, Montana	S½NW¼ Sec 23, T4S, R32E	x	x	x	x	x
Beauvais Creek near St. Xavier, Montana	Sec 15, T4S, R30E	x A/	x A/	x A/		x A/
Woody Creek near St. Xavier, Montana	E½NE¼ Sec 27, T3S, R32E	x	x	x	x	x
Bighorn River near Hardin, Montana	NW¼ Sec 19, T1S, R34E	x	x	x	x	x
Little Bighorn River at state line near Wyola, Montana	SW¼NW¼ Sec 36, T9S, R33E	x A/	x	x	x	x
Little Bighorn River below Pass Creek near Wyola, Montana	W½SW¼ Sec 35, T7S, R35E	x A/	x A/	x	x A/	x
Owl Creek near Lodge Grass, Montana	NE¼NW¼ Sec 30, T6S, R36E	x	x	x	x	x
Lodge Grass Creek above Willow Creek Diversion	W½NW¼ Sec 19, T8S, R34E	x	x	x	x	x
Lodge Grass Creek at Lodge Grass, Montana	NE¼SE¼ Sec 13, T6S, R35E	x	x	x	x	x
Reno Creek near Garryowen, Montana	NW¼NW¼ Sec 11, T4S, R35E	x	x	x	x	x
Little Bighorn River near Hardin, Montana	NE¼NE¼ Sec 19, T1S, R34E	x A/	x A/		x A/	x A/
Tullock Creek near McRae, Montana	SE¼SE¼ Sec 36, T1N, R35E	x	x	x	x	x
Sarpy Creek near McRae, Montana	SE¼NE¼ Sec 33, T1N, R37E	x	x	x	x	x

Table 38

SUMMARY OF CROW 208 STREAM SAMPLING SITES
(continued)

Station Name	Location	Data Type: Flow	Common Ions	Metals	Nutrients	Suspended Sediment
East Fork Sarpy Creek near McRae, Montana	SW¼ Sec 22, T1N, R36E	x	x	x	x	x
Davis Creek near Busby, Montana	NE¼SE¼ Sec 10, T4S, R38E	x	x	x	x	x
Thompson Creek near Kirby, Montana	NE¼SW¼ Sec 28, T4S, R38E	x	x	x	x	x
Corral Creek near Kirby, Montana	SE¼ Sec 28, T5S, R38E	x	x	x	x	x
Indian Creek near Kirby, Montana	SE¼ Sec 36, T6S, R38E	x	x	x	x	x

A/ Flow or water quality data presently obtained by USGS.



NOTE: Sampling sites on East Fork Sarpy Creek, Indian Creek near Kirby, Corral Creek near Kirby, Thompson Creek near Kirby and Davis Creek near Busby located off map.

FIGURE 22 CROW INDIAN BASELINE DATA SAMPLING PROGRAM MAP

Table 38a

SUMMARY OF CROW 208 STREAM SAMPLING SITES FOR BIOLOGICAL WATER QUALITY STUDY

Station Name	Location	Biological Data A/	Physical Parameters B/
PC-1	NW¼ Sec 8, T6S, R26E	x	x
PC-2	NE¼NW¼NW¼ Sec 5, T5S, R26E	x	x
PC-3	N½NW¼ Sec 31, T1N, R28E	x	x
BHR-1	NW¼NE¼ Sec 16, T6S, R31E	x	x
BHR-2	NW¼NE¼ Sec 27, T4S, R32E	x	x
BHR-3	NW¼ Sec 19, T1S, R34E	x	x
LBH-1	SW¼NW¼ Sec 36, T9S, R33E	x	x
LBH-2	NW¼SE¼, T6S, R35E	x	x
LBH-3	NE¼NE¼ Sec 19, T1S, R34E	x	x

A/ Total standing crop and biomass per unit volume for macroinvertibrates as dry and ash-free weight per unit volume and fecal coliform numbers.

B/ Flow rate, dissolved oxygen, pH, alkalinity, temperature, turbidity and conductivity.

Source: HKM Associates

the recommended levels until Pryor Creek reaches Pryor. Total dissolved solids and sulfate concentrations do not approach or exceed the secondary recommended levels until Pryor Creek approaches the reservation boundary.

Pryor Creek is suitable for stock consumption throughout the reservation. However, the total dissolved solids content of East Fork Creek equals or exceeds the upper limits for various type of stock. The sodium hazard for irrigation water is generally low for Pryor Creek throughout the reservation but high for East Fork Creek. The salinity hazard for irrigation water is low to moderate for Pryor Creek and all tributaries sampled except East Fork Creek, which is severe.

No noticeable increase in concentrations of nutrients or heavy metals, or changes in field parameters were in evidence during the sampling. Problems were observed to occur with sediment build up and soil erosion. Poor grazing and farming practices are known to lead to accelerated erosion and sediment yield, but due to the erosive conditions which exist naturally within the basin shales, it is difficult to quantify the relationship between geologic and man-induced erosion.

In the future, land usage on the highly erosive soils must be monitored. Determining the virgin water and soil conditions in the Pryor Creek basin will require significantly more study on a site specific basis.

Bighorn River Basin

General Setting

Within the Crow Indian reservation, the Bighorn River drains approximately 1,600 square miles and is by far the largest water source on the reservation. It has been completely regulated on the reservation since 1965 when Yellowtail Dam was constructed forming Bighorn Reservoir. On the east side of the river there are two major tributaries, Soap Creek which drains 110 square miles and Rotten Grass Creek with a watershed encompassing 160 square miles. Both of these streams rise on the north slope of the Bighorn Mountains at elevations in excess of 7,000 feet and run generally northward to their respective confluences with the Bighorn River. Although each stream has its headwaters in the mountains, a significant portion of both basins are in a prairie environment. West of the Bighorn River, Beauvais and Woody Creeks are the major tributaries. Both of these drainages have their headwaters on the low divide between Pryor Creek and the Bighorn River with elevations of less than 5,000 feet with the exception of the southern segment of the Beauvais Creek drainage. In this area, several tributaries drain a small portion of the north slope of the Pryor Mountains where elevations slightly above 6,000 feet are encountered. In general, however, the western tributaries reflect a prairie drainage condition.

Summary and Conclusions

The sampling site located on the Bighorn River at Hardin, defines the conditions of the Bighorn drainage within the Crow Indian reservation. Water

of the Bighorn River passes through the reservation with little change in the dissolved solids content from St. Xavier to Hardin. This indicates that the tributary streams have little effect on the overall water quality of the Bighorn River. Data collected from the sites on Soap, Rotten Grass and Woody Creeks indicated that these tributaries contributed the following: 1 to 7 percent of the flow; 1 to 65 percent of the suspended sediment discharge; 1 to 7 percent of the TDS discharge; and 1 to 8 percent of the sulfate discharge at Hardin. The high discharges defined above generally correspond to the high flow period for the sampling period (April 1977) and the low discharges to the low flow periods (November 1976, January and July 1977). The limited data indicates that ground water has some influence on total dissolved solid discharges in the Bighorn River at Hardin. Insufficient data was available, however, to evaluate its effect on the Bighorn River.

Water in the Bighorn River basin is generally acceptable for drinking, irrigation and livestock watering. Of the three uses, it appears the water is least suitable for drinking water due to the dissolved solids and coliform counts. High dissolved solids concentrations lead to taste and odor problems, fixture staining and corrosive action to pipes and hot water heaters. Because of high coliform counts, all water would need to be disinfected prior to domestic use.

Little Bighorn River Basin

General Setting

The Little Bighorn River system has two major upper watershed tributaries, Pass Creek and Lodge Grass Creek, which, together with the mainstem system in Wyoming, have their headwaters on the northeast flank of the Bighorn Mountains. Maximum water shed elevations range from over 10,000 feet in the Little Bighorn headwater area to 9,800 for Lodge Grass Creek and 8,700 for Pass Creek. Annual precipitation varies with elevation in the basin with annual means exceeding 30 inches per year in the headwaters of the Little Bighorn River and Lodge Grass Creek. Average annual precipitation is 20 inches per year in the higher elevations in Pass Creek. The mainstem system is joined by two other larger tributaries along its length - Owl Creek and Reno Creek. Owl Creek has its source in the lower elevation of the Wolf Mountains which form part of the eastern divide of the Little Bighorn basin. Maximum altitudes in this area reach approximately 5,000 feet. This elevation does not provide a marked climatic influence in the headwaters and the annual precipitation slightly exceeds 16 inches per year. Reno Creek has its headwaters in the Rosebud Mountains, an area very similar to the Wolf Mountains in elevation and climate. Runoff yield is expected to be somewhat lower in the northern sector of the reservation.

Summary and Conclusions

The sampling site located on the Little Bighorn River at Hardin, defines the condition of the Little Bighorn drainage within the Crow Indian reservation. The Little Bighorn River changes from a high quality calcium bicarbonate type as the river enters the reservation to a mixed type with the dominant ions being sodium, magnesium, bicarbonate and sulfate. Available data indicates that the

tributaries originating on the reservation have a significant effect on the quality of the Little Bighorn River with respect to suspended sediment, total dissolved solids, sodium and sulfate. Data collected during the 208 sampling program at three sites on the Little Bighorn River indicated that in the months of April and June 1977, the reservation contributions amounted to about 90 percent and 50 percent, respectively, of the total dissolved solids discharge at Hardin. Data obtained in the Crow Indian agricultural nonpoint source study indicated that principal tributaries of the Little Bighorn River (Pass, Owl, Lodge Grass, and Reno Creeks) contributed approximately 53 percent of the total dissolved solids discharge for the period between September 15, 1976 and September 15, 1977. Available sulfate discharge data indicated that the Little Bighorn drainage within the reservation boundary could have contributed as much as 90 percent to 98 percent of the estimated total sulfate discharge in the Little Bighorn River at Hardin during the 1976-1977 program for which 208 data is available. Water in the Little Bighorn River basin within the Crow Indian reservation is generally acceptable for drinking (with appropriate treatment), irrigation and livestock watering except Reno Creek. Water in Reno Creek would, generally, be unsuitable for irrigation due to its high salinity, sodium and bicarbonate concentrations.

(4) Fort Belknap 208 Program

The Fort Belknap Indian reservation received a 208 grant in early 1978 to investigate three suspected water quality problem areas. These were: domestic well contamination; mine tailings leaching; and an irrigation diversion structure which prevented easy fish passage. A brief summary of the findings of these three studies is presented below.

Of 103 domestic wells sampled for chemical analyses during the monitoring program, 48 samples exceeded recommended drinking water standards. Twenty-five of these wells were also randomly sampled for bacteriological analysis, and two wells were found to be contaminated. These results were submitted to the Indian Health Service for further evaluation.

Samples of leachate from the Little Ben mine indicated there were unacceptable concentrations of arsenic and lead in the leachate. Recommendations were made to alleviate this problem.

The problem with the irrigation diversion structure was not investigated through actual field monitoring. Instead, efforts were made to obtain some type of corrective action by the responsible project representatives.

A continuation program will include stream sampling at approximately 19 stations twice during the summer of 1980. Also, approximately 75 bacteriological samples will be collected from domestic wells. This monitoring program will attempt to establish baseline water quality conditions on the reservation, as well as identify point and nonpoint source of problems which have not yet been adequately investigated.

(5) Rocky Boy 208 Program

The Rocky Boy 208 program was primarily oriented toward water quantity investigations since the major concern appeared to be a need for adequate water supplies. The USGS monitored several stream sites but this data was never summarized and reported by the 208 program. The study was aimed at identifying potential storage and diversion sites which could be developed to preserve a certain portion of the reservation water.

(6) Fort Peck 208 Program

The Fort Peck 208 program established a baseline water quality monitoring network in 1979 after previous efforts were delayed due to staff turnover. The monitoring program included upstream and downstream stations on Big Muddy Creek, Porcupine Creek, Wolf Creek, and Tule Creek. Analyses for the following general parameter categories were accomplished: field parameters and dissolved solids, common ion constituents, nutrients and other constituents, and metals and miscellaneous constituents. Although sampling was initiated during June, 1979 subsequent staff turnoff has delayed receipt of the draft water quality report. This information should be available in May, 1980.

C. Evaluation of Water Quality Trends

1. Chemical/Physical

Water quality monitoring activities have increased substantially in Montana over the past few years both in scope and frequency. These increases are due to public demand for accurate information about harmful pollutants in the environment and to the passage of State and Federal Legislation, namely, the Montana Water Quality Act and the Federal Water Pollution Control Act of 1972 (Public Law 92-500). To fulfill the requirements of these legislative mandates State and Federal Agencies have planned and developed extensive monitoring networks which have generated a mass of environmental quality data.

The purpose of this section is to present useful analytical summaries for Montana on water quality data resident in the STORET data storage and retrieval system. This section does not attempt to classify or precisely determine water quality or to analyze detailed cause and effect relationships. It attempts, rather, to impart a sense of status and trend (i.e. improvement, degradation, etc.), by observing water quality measurements not only for current severity but also for changes over successive time periods.

Water quality data (1975-1978) for the active monitoring stations in Montana were retrieved from STORET (EPA's computerized water quality data base) and screened through computerized trending techniques. Table 39 shows the forty-six STORET water quality parameters which were grouped into general categories of temperature, dissolved oxygen, pH, bacteria, trophic potential, dissolved solids, suspended solids, aesthetics, metals, and inorganic toxicants for purposes of this trend study.

Parameters were analyzed in a two step process. First, to describe pollution severity, a water quality indicator (WQI) was computed for each observation of each parameter at all active stations and averaged on a monthly basis. The WQI may vary from zero to one hundred. A WQI less than 20 represents generally acceptable quality. The range from 20 to 60 signifies exceedence of water quality standards/criteria and the WQI greater than 60 represents exceedence of a severe nature.

Secondly, to determine pollution trends, the 15th, 50th (median) and 85th percentile values for two time periods were compared for each parameter with sufficient data. A standard statistical test, requiring at least six observations for a parameter in each time period was used to test for a significant difference between the two time periods. Significant changes in the 50th percentile measurements are generally indicative of overall changes in concentrations, while significant changes in the 85th percentile measurement (15th percentile for dissolved oxygen) are generally indicative of changes during critical periods. Detailed procedures for severity and trend analysis are described in an EPA report titled "Water and Air Quality Trends in Region VIII" (EPA-908/2-79-001).

STORET Parameter	STORET Number	Criteria/Std.	Group
Temperature °C	10	29oC	Temp.
Temperature °F	11	29oC	
D.O.	300	5 mg/l	DO
pH	400	6.5-8.5	pH
Fecal Coliform	31616	200	
"	31615	200	Fecal Coli.
"	31625	200	
Total Coliform	31501	1000	Total Coli.
"	31505	1000	
NO_2 & NO_3	630	0.6 mg/l	
NO_3 - N	620	"	
Nitrate	71850	"	
Nitrate	71851	"	
Total Phosphate	665	.05 mg/l	Trophic
Total Phosphate	666	"	
Ortho Phosphate	70507	"	
Ortho Phosphate	660	.09 mg/l	
Dis. O.-Phos.	671	.03 mg/l	
Turbidity	70	25	
Turbidity	76	25	Aesthetic
Oil & Grease	550	2	
Dissolved Solids	70300	500 mg/l	
"	515	"	
"	70301	"	Dis. Solids
Conductivity	95	750 µmho	
Suspended Solids	530	25 mg/l	
"	70299	"	Susp. Solids
"	80154	"	
Arsenic Dis.	1000	50 µg/l	
" Total	1002	50 µg/l	
Cadmium Dis.	1025	3 "	
Cadmium Total	1027	3 "	
Chromium Dis.	1030	50 "	
" Total	1034	50 "	
Copper Dis.	1040	20 "	
" Total	1042	20 "	Metals
Lead Dis.	1049	30 "	
" Total	1051	30 "	
Zinc Dis.	1090	80 "	
" Total	1092	80 "	
Mercury Dis.	71890	0.5 "	
" Total	71900	0.5 "	
Cyanide	720	.02 mg/l	
Un-ionized NH_3	619	.02 "	
"	608	.02 "	Inorg. Tox.
"	610	.02 "	

Table 39 . STORET parameters and pollutant groups analyzed for water quality trends.

This section contains four major tables depicting water quality conditions and trends at Montana stations in STORET. Table 40, Ranking of Critical Water Quality Stations by Pollutant Group, is a summary of stations where the highest WQI values were noted.

Table 41, Station and Parameter Group Coverage, lists the active water quality monitoring stations in the state and a count of the number of data observations for each parameter group present in the STORET data system for the year 1978.

Table 42, Critical Stations and Parameters, utilizes the WQI calculation procedure to determine and display monthly standard exceedences by pollutant group and station location. This table of pollution severity also provides the average yearly WQI calculation for critical stations and a ranking factor for each station and parameter group. A ranking of 1 defines the station as the highest critical level in the State. This table reports on 1978 data only.

Table 43, Water Quality Trends, lists stations where parameter groups exhibited significant changes over time as determined by statistical tests. This table shows quality improvement or degradation in each parameter group and points out those groups which are at or approaching critical levels. Data for 1975, 1976 and 1977 were trended against data for 1978 in determining this table.

2. Biological

Composite periphyton and macroinvertebrate samples were collected seasonally at 85 stream and river sites in Montana between 1977 and 1979. Such collections represent the core of the state's biological monitoring program. Indicators derived from these collections reflect water quality over an extended period of time prior to sampling. Other parameters reflect water quality only at the time of sampling. The most accepted and useful expression of water quality based on these biological collections is the diversity index, usually the Shannon-Weaver Index (Weber, C.I. (ed), "Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents," EPA-670/4-73-001).

Diatom and macroinvertebrate diversity index values have been computed by pollution biologists for samples collected over a broad range of water quality conditions. Generally, water quality may be related to Shannon-Weaver diversity values in the following manner:

Water Qaulity	Diatom Diversity	Macroinvertebrate Diversity	Overall Diversity
Excellent	> 4.50	> 3.50	> 4.00
Good	3.50-4.50	2.50-3.50	3.00-4.00
Fair	2.50-3.50	1.50-2.50	2.00-3.00
Poor	< 2.50	< 1.50	< 2.00

Table 40 Ranking of Critical Water Quality Stations by Pollutant Group

		WQI*
Phosphorus		
1.	Powder R at Moorhead	58
2.	Milk R at Nashua	36
3.	Pumpkin Cr nr Miles City	35
4.	Yellowstone R nr Terry	31
Turbidity		
1.	Powder R at Moorhead	86
2.	Rosebud Cr at Mouth	61
3.	Pumpkin Cr nr Miles City	59
4.	Rosebud Cr nr Colstrip	58
5.	Yellowstone R nr Terry	54
Dissolved Solids		
1.	Mizpah Cr at Olive	92
2.	E Fork Armells Cr nr Colstrip	84
3.	Pumpkin Cr nr Loesch	78
4.	Armells Cr nr Forsyth	71
5.	Redwater R at Circle	65
6.	Hanging Woman Cr nr Birney	59
Suspended Sediment		
1.	Powder R at Moorhead	87
2.	Missouri R nr Culbertson	83
3.	Musselshell R at Mosby	72
4.	Tongue R at Miles City	66
5.	Prairie Elk Cr nr Oswego	63
6.	Milk R at Nashua	62
Trace Elements		
1.	Redwater R at Vida	As=100

* Average annual water quality indicator (WQI) value. A range from 20 to 60 signifies exceedence of water quality standards/criteria and the WQI greater than 60 represents exceedences of a severe nature.

Table 41 STATION AND PARAMETER GROUP COVERAGE.
Water Quality Data for Year 1978 - Montana

STATION	TEMP	DO	PH	FECAL COLI	BIT	PHOS	TURB	DIS SOLID	SUSP SOLID	NH3	METALS
112WRD 06054500											
MISSOURI RIVER AT TOSTON, MT.	37	37	37	12	12	24	12	61	8	12	56
21MTHDWQ 304110											
MISSOURI R BL TOWNSEND MT											
112WRD 06090800											
MISSOURI RIVER AT FORT BENTON, M											
112WRD 06109500											
MISSOURI RIVER AT VIRGELLE, MT.	36	36	36	12	12	24	12	60	9	12	55
121MBRCF 293007											
MISSOURI R NEAR ZORTMAN	4		4		5	5	3	3	3	5	8
121MBRCF 293003											
MISSOURI RIVER A FT PECK	4		4			1				3	4
112WRD 06132000											
MISSOURI RIVER BELOW FORT PECK D	36	36	36	12	12	23	12	58	7	12	56
112WRD 06177000											
MISSOURI RIVER NEAR WOLF POINT,											
112WRD 06185500											
MISSOURI RIVER NEAR CULBERTSON,	36	35	36	11	12	24	12	60	6	12	70
112WRD 06191500											
YELLOWSTONE RIVER AT CORWIN SPRI											
112WRD 06192500											
YELLOWSTONE RIVER NEAR LIVINGSTO	11		12			30		21			
112WRD 06214050											
CLARKS FORK YELLOWSTONE RIVER NE											
112WRD 06214100											
YELLOWSTONE RIVER NEAR LAUREL, M											
112WRD 06214500											
YELLOWSTONE RIVER AT BILLINGS MT	42	37	37	11	12	24	12	62	13	12	56
112WRD 06217500											
YELLOWSTONE RIVER AT HUNTLEY, MT	24	24	24	24	24	24	24	60	33	24	14
112WRD 06218000											
YELLOWSTONE RIVER AT CUSTER, MT.											
112WRD 06294840											
YELLOWSTONE RIVER AT MYERS, MT.											
112WRD 06295000											
YELLOWSTONE RIVER AT FORSYTH, MT	26	12	12	12	12	12	9	24	20	12	14
112WRD 06296120											
YELLOWSTONE RIVER NEAR MILES CIT	25	25	25	24	25	25	25	61	34	25	14
112WRD 06326530											
YELLOWSTONE RIVER NEAR TERRY, MT	14	14	14		14	14	11	28	11	14	14
121MBRCF 293000											
YELLOWSTONE R NEAR SIDNEY											
112WRD 06329500											
YELLOWSTONE RIVER NEAR SIDNEY, M	62	47	47	22	24	35	31	82	47	23	70
111ONET 290055											
YELLOWSTONE RIVER AT SIDNEY	42		41					34			
112WRD 06287000											
BIGHORN RIVER NEAR ST. XAVIER, M	12		12			30		22			
112WRD 06288500											
BIGHORN RIVER NEAR HARDIN, MT.											

Table 41 (continued). STATION AND PARAMETER GROUP COVERAGE.
Water Quality Data for Year 1978 - Montana

STATION	TEMP	DO	PH	FECAL COLI	NITT	PHOS	TURB	DIS SOLID	SUSP SOLID	NUT	METALS
111ONET 290104											
BIG HORN RIVER AT HARDIN											
112WRD 06294700											
BIGHORN RIVER AT BIGHORN, MT.	37	37	37	12	13	26	13	63	10	13	70
112WRD 12323800											
CLARK FORK NEAR GALEN, MT.											
112WRD 12324200											
CLARK FORK AT DEER LODGE, MT.											
1119C050 293005											
CLARK FORK ABOVE MISSOULA											
112WRD 12340500											
CLARK FORK ABOVE MISSOULA, MT.											
1119C050 293003											
CLARK FORK NEAR ALBERTON MONTANA											
1119C050 293002											
CLARK FORK AT PLAINS MONTANA.											
112WRD 12389000											
CLARK FORK NEAR PLAINS, MT.											
112WRD 12391000											
CLARK FORK AT THOMPSON FALLS, MT											
112WRD 06324500											
POWDER RIVER AT BOORHEAD, MT.	17	12	14		14	16	9	30	10	14	
112WRD 06308160											
PUMPKIN CREEK NEAR LOESCH, MT.	9	9	9		9	9	8	18	8	9	14
112WRD 06308170											
LITTLE PUMPKIN CREEK NEAR VOLBOR											
112WRD 06308190											
PUMPKIN CREEK NEAR VOLBORG, MT.											
112WRD 06308400											
PUMPKIN CREEK NEAR MILES CITY MT	12	10	12		13	14	8	25	8	12	21
112WRD 06326050											
MIZPAH CREEK AT OLIVE, MT.	10	8	10		10	12	6	22	6	10	18
112WRD 06326200											
MIZPAH CREEK NEAR VOLBORG, MT.	2		2		2	4		6		2	
112WRD 06329200											
BURNS CREEK NEAR SAVAGE, MT.	12	12	12		12	12	9	24	9	12	49
112WRD 06178000											
POPLAR RIVER AT INTERNATIONAL BO	11	11	11	7	11	33	11	22	7	11	49
112WRD 06178150											
POPLAR RIVER NEAR SCOBEY	11	11	11	6	11	33	11	22	6	11	49
112WRD 06179000											
EAST FORK POPLAR RIVER NEAR SCOB	11	11	11	6	11	33	11	22	7	11	49
112WRD 06179200											
POPLAR RIVER ABOVE WEST FORK NEA	11	11	11	8	11	33	11	22	7	11	49
112WRD 06179500											
WEST FORK POPLAR RIVER AT INTERN	9	8	8	3	9	25	9	18	5	9	49
112WRD 06180200											
WEST FORK POPLAR RIVER NEAR FOUR											
112WRD 12355500											
N F FLATHEAD RIVER NEAR COLUMBIA	12	8	8	8	8	16	8	24	10	16	42

Table41(Continued). STATION AND PARAMETER GROUP COVERAGE.
Water Quality Data for Year 1978 - Montana

STATION	TEMP	DO	PH	FECAL COLI	NIT	PHOS	TURB	DIS SOLID	SUSP SOLID	NRS	METALS
112WRD 12302055											
FISHER RIVER NEAR LIBBY, MT.											
112WRD 12303400											
ROSS CREEK NEAR TROY MT	3	3	3		3	4	3	6	3	3	42
112WRD 12303430											
STANLEY CREEK NEAR TROY MT	3	3	3		3	4	3	6	3	3	42
112WRD 12303490											
LAKE CREEK NEAR TROY MT	3	3	3		3	4	3	6	3	3	42
112WRD 06016000											
BEAVERHEAD RIVER AT BARRETTS, MT	9		9			25		18			
112WRD 06018500											
BEAVERHEAD RIVER NEAR TWIN BRIDG	11		11			27		21			
112WRD 06088300											
MUDDY CREEK NEAR VAUGHN, MT.	15		12			30		22	3		
112WRD 06088500											
MUDDY CREEK AT VAUGHN, MT.	15		12			30		22	3		
112WRD 06080900											
SUN RIVER BL DIVERSION DAM, NEAR	9		9			23		16			
112WRD 06089000											
SUN RIVER NEAR VAUGHN, MT.	12		12			28		22			
112WRD 06130500											
MUSSELSHELL RIVER AT MOSBY, MT.	37	37	37	13	12	24	12	61	9	12	56
112WRD 06172310											
MILK RIVER AT TAMPICO, MT.											
112WRD 06174500											
MILK RIVER AT NASHUA, MT.	36	36	36	12	12	24	12	60	9	12	56
112WRD 06154400											
PEOPLES CREEK NEAR HAYS, MT.											
112WRD 06175540											
PRAIRIE ELK CREEK NEAR OSWEGO MT	11	11	11		11	11	8	20	8	11	28
112WRD 06177500											
REDWATER RIVER AT CIRCLE, MT.	11	11	11		11	11	8	21	8	11	28
112WRD 06177825											
REDWATER RIVER NEAR VIDA, MT.	10	10	10		9	10	7	20	7	9	49
112WRD 06137570											
BOXELDER CREEK NEAR ROCKY BOY MT	10	10	10	10	10	10	9	20	9	10	42
112WRD 06217750											
FLY CREEK AT POMPEYS PILLAR, MT.	12		12			32		23			
112WRD 06288200											
BEAUVAIS CREEK NEAR ST. XAVIER,	7	7	7	7	7	7		21	7		7
112WRD 06294000											
LITTLE BIGHORN RIVER NEAR HARDIN	12		11			30		20			
112WRD 06294940											
SARPY CREEK NEAR HYSHAM, MT.	10	8	10		10	12	6	22	6	10	27
112WRD 06294980											
EAST FORK ARMELLS CREEK NEAR COL	8	8	8		8	8	6	16	6	8	21
112WRD 06294991											
WEST FORK ARMELLS CREEK NEAR FOR											
112WRD 06294995											
ARMELLS CREEK NEAR FORSYTH, MT.	11	9	11		11	13	7	24	7	11	18

Table 41 (Continued). STATION AND PARAMETER GROUP COVERAGE.
Water Quality Data for 1978 - Montana

STATION		TEMP	DO	PH	FECAL COLI	NIT	PHOS	TURB	DIS SOLID	SUSP SOLID	NH3	METALS
112WRD	06295250											
ROSEBUD CREEK NEAR COLSTRIP, MT.		9	9	9		8	8	7	17	7	8	28
112WRD	06295400											
ROSEBUD CREEK ABOVE PONY CREEK,												
112WRD	06295500											
ROSEBUD CREEK NEAR ROSEBUD, MT.												
112WRD	06296003											
ROSEBUD CREEK AT MOUTH, NEAR ROS		11	9	11		11	13	7	24	7	11	25
112WRD	06306300											
TONGUE RIVER AT STATE LINE NR DE		14	11	13	12	25	14	12	28	12	13	28
112WRD	06307500											
TONGUE RIVER AT TONGUE R DAM, NF		11	9	11		11	13	7	24	7	11	37
112WRD	06307600											
HANGING WOMAN CREEK NEAR BIRNEY,		9	9	9		9	9	7	18	7	9	14
112WRD	06307610											
TONGUE RIVER BL HANGING WOMAN C.		12	12	12		12	12	9	24	9	12	14
112WRD	06307830											
TONGUE R BL BRAUDENBERG BRIDGE,		11	9	9		9	9	7	17	12	9	21
112WRD	06308500											
TONGUE RIVER AT MILES CITY, MT.		39	36	36	12	13	26	13	62	11	13	70
112WRD	06307740											
OTTER CREEK AT ASHLAND, MT.		9	9	9		9	9	7	18	7	9	14

Table 42 CRITICAL STATIONS AND PARAMETERS.

STATION	JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC	AVG WQI	RKG.
Dissolved Oxygen			
Pumpkin Cr nr Loeser	X X		
Pumpkin Cr nr Miles City	X		
Mizpah Cr at Olive	X X X		
W FK Poplar R at Intl Bdry	X		
Fecal Coliform Bacteria			
Yellowstone R at Huntley	● ○ ○	30	
Yellowstone R at Forsyth	○	15	
Musselshell R at Mosby	○	14	
Milk R at Nashua	○	16	
Boxelder Cr nr Rocky Boy	○	17	
Beauvais Cr nr St. Xavier	○	21	
Tongue R at WY-MT line	○	20	
Tongue R at Miles City	○	11	
Phosphorus			
Missouri R at Virgelle	●	20	
Missouri R nr Culbertson	● ○ ●	28	
Yellowstone R at Forsyth	○	15	
Yellowstone R nr Miles City	○	20	
Yellowstone R nr Terry	● ● ○ ●	31	4
Yellowstone R nr Sidney	● ● ○	29	
Big Horn at Big Horn	●		
Powder R at Mcorhead	● ● ● ● ●	58	1
Pumpkin Cr nr Miles City	● ● ○	35	3
W FK Poplar R at Intl Bdry	C		
Musselshell R at Mcsby	● ○ ● ●	33	
Milk R at Nashua	● ○ ●	36	2
Prairie Elk Cr nr Oswego	● ● ●	33	
Redwater R at Circle	●	12	
Boxelder Cr nr Rocky Boy	○	23	

X Minor exceedence of standards (for Temperature, DO, and pH only)

○ At or approaching critical levels ● Above critical levels – Insufficient data

Table 42. CRITICAL STATIONS AND PARAMETERS.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG WQI	PKG.
Phosphorus Continued														
Redwater R nr Vida			○										12	
Beauvais Cr nr St. Xavier											●			
Armells Cr nr Forsyth			○										15	
Rosebud Cr nr Colstrip			○		●								31	
Rosebud Cr at Mouth			●	○	●								32	
Tongue R at Miles City			●		●						●		27	
Otter Cr at Ashland			●										19	
Turbidity														
Missouri R at Virgelle			●										31	
Missouri R nr Culbertson				●	●	○							37	
Yellowstone R at Billings			○		○								17	
Yellowstone R at Huntley											○		16	
Yellowstone R at Forsyth			●	○	●								33	
Yellowstone R nr Miles City					●								20	
Yellowstone R nr Terry			●	●	●	●	●						54	5
Yellowstone R nr Sidney			●	●	●	●	○				○		44	
Big Horn R at Big Horn			●		●	○							30	
Powder R at Moorehead	●		●	●	●	●	●	●					86	1
Pumpkin Cr nr Miles City			●				●				●		59	3
Poplar R nr Scobey											●		15	
W FK Poplar R at Intl Bdry			●										10	
Musselshell R at Mosby			●	○	●	●	●				●		47	
Milk R at Nashau			●	●	●		○				●		43	
Prairie Elk Cr nr Oswego			●		●						●		51	5
Redwater R at Circle			●										21	
Redwater R nr Vida			●										29	
Sarpy Cr nr Hysham			○										31	
Armells Cr nr Forsyth			●		●								44	
Rosebud Cr nr Colstrip			○	●	●	○							58	4

X Minor exceedence of standards (for Temperature, DO, and pH only)

○ At or approaching critical levels ● Above critical levels — Insufficient data

Table 42. CRITICAL STATIONS AND PARAMETERS.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG WQI	RKG.
Turbidity Continued														
Rosebud Cr abv Pony Cr.				●	●	●	●							
Rosebud Cr nr Rosebud		○		●	●	●	●	●						
Rosebud Cr at Mouth			●	●	●								61	2
Hanging Woman Cr nr Birney			●		●								26	
Tongue R blw Hanging Woman Cr						○							18	
Tongue R blw Brandenberg Br					●	●							35	
Tongue R at Miles City			●	●	●								47	
Otter Cr at Ashland			●		○								34	
Total Dissolved Solids (TDS)														
Powder R at Moorhead	○	○		○				○	○	○		○	43	
Pumpkin Cr nr Loesch				●	●	●	●	●	●			●	78	3
Pumpkin Cr nr Miles City									○				43	
Mizpah Cr at Olive				●	●	●	●	●	●		●	●	92	1
Mizpah Cr nr Volborg								○		●				
Burns Cr nr Sage					○								36	
E FK Poplar R nr Scobey	○												33	
Poplar R above W Fork	○												31	
Muddy Cr nr Vaughn				○									27	
Musselshell R at Mosby	●	●		○					○	○	○	○	45	
Milk R at Nashua	○												27	
Prairie Elk Cr nr Oswego					○				○		○	○	44	
Redwater R at Circle	●			●	●			●	●	●	●	●	65	5
Redwater R nr Vida				○	○	●		○	○	●	●	●	53	
Fly Cr at Pomeys Pillar	●	○	●	●	○	●			○				52	
Sarpy Cr nr Hysham		○		●	○	●				○		○	56	
E FK Armells Cr nr Colstrip		●	●	●	●	●	●			●		●	34	2
W FK Armells Cr nr Forsyth				●	○	●			●	●		●		
Hanging Woman Cr nr Birney		○		●	○	●			●		●	●	59	6
Armells Cr nr Forsyth								●		●			71	4
Otter Cr at Ashland		●		●		●			○	●		●	53	
Beavais Cr at St. Xavier		○											36	

X Minor exceedence of standards (for Temperature, DO, and pH only)

○ At or approaching critical levels ● Above critical levels – Insufficient data

Table 42. CRITICAL STATIONS AND PARAMETERS.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG WQI	RNG.
Suspended Sediment														
Missouri R at Toston		○	○										23	
Missouri R at Virgelle			●										29	
Missouri R blw Fort Peck Dam			●										19	
Missouri R nr Culbertson				●	●	●	○	●	●				83	2
Yellowstone R at Billings					●								32	
Yellowstone R at Forsyth			●		●	●			○				44	
Yellowstone R nr Miles City						●							22	
Yellowstone R nr Terry			●	●	●	●	●						59	
Yellowstone R nr Sidney			●	○	●	●	○		○				41	
Big Horn R at Big Horn			●	○	●	●	●						48	
Powder R at Moorhead	●		●	●	●	●	●	●	●				87	1
Pumpkin Cr nr Miles City			●				●		●				58	
Muddy Cr nr Vaughn			●				●							
Musselshell R at Mosby			●	○	●	●	●	○	●				72	3
Milk R at Nashau			●	●	●				●				62	6
Prairie Elk Cr nr Oswego	○		●		●				●				63	5
Redwater R at Circle			●										40	
Redwater R nr Vida			●										41	
Beauvais Cr nr St. Xavier		●	○			●			●				57	
Sarpy Cr nr Hysham			○										34	
Armells Cr nr Forsyth			○		●	●							49	
Rosebud Cr nr Colstrip			○	●	●	●							59	
Rosebud Cr at Mouth			●	●	●	○							62	
Hanging Woman Cr nr Birney					○	○							25	
Tongue R blw Brandenberg			○		●	●							45	
Tongue R at Miles City			●	○	●	●			●				66	4
Otter Cr at Ashland			○		○								38	
Nitrate														
Prairie Elk Cr nr Oswego					○									

X Minor exceedence of standards (for Temperature, DO, and pH only)

○ At or approaching critical levels ● Above critical levels – Insufficient data

Table 42. CRITICAL STATIONS AND PARAMETERS.

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG ACC PKG.
Trace Metals													
Missouri R nr Culbertson									Hg 24	Hg 29		Hg 31	
Yellowstone R nr Sidney									Hg 21			Hg 29	
Big Horn R at Big Horn					Hg 22								
Burns Cr nr Savage										Hg 22	Hg 24		
Poplar R nr Scobey										Hg 21		Hg 21	
E FK Poplar R nr Scobey						Hg 21				Hg 21			
Poplar R abv W Fork												Hg 21	
W FK Poplar R at Intl Bdry						Hg 21							
Musselshell R at Mosby			Hg 37										
Prairie Elk Cr nr Oswego						Hg 26					Hg 22		
Redwater R at Circle			Hg 22			Hg 21				Hg 22			
Redwater R at Vida	As 100					Hg 21				Hg 21			
Beauvais Cr nr St. Xavier						Hg 21							
Rosebud Cr at Mouth				Hg 21									
Tongue R at Tongue R Dam				Hg 21									
Tongue R at Miles City					Hg 21								

Table 43 WATER QUALITY TREND TABLE: Stations and Parameters where Significant Statistical Differences were Observed.

STATION	TEMPERATURE	DISSOLVED OXYGEN	PH	BACTERIA	NITROGEN	PHOSPHOROUS	TURBIDITY	DISSOLVED SOLIDS	SUSPENDED SOLIDS	PHENOLS	METALS
Missouri R. @ Toston		D									
Missouri R. bl Fort Peck		D	I					D			
Missouri R. nr Culberson		D	I					D			
Yellowstone R. @ Billings		D	D					I	D*		
Yellowstone R. @ Huntley		I		I*							
Yellowstone R. @ Forsyth								D	D*		
Yellowstone R. nr Miles City								D			
Yellowstone R. nr Terry								D			
Yellowstone R. nr Sidney			D					D	D*		
Big Horn R. nr St. Xavier								D			
Big Horn R. at Bighorn		D			D			D	D*		
Muody Creek nr Vaughn						D					
Sun River nr Vaughn						D					
Musselshell R. @ Mosby		D						I*			
Milk River @ Nashua		D	D					I*			
Red Water R. @ Circle										D*	
Box Elder Cr nr Rocky Bay										D*	
Armell's Cr nr Forsyth							D*		D*		
Rosebud Cr nr Colstrip					D				D*		
Tongue River @ State Line				D*							
Tongue R. @ Tongue R. Dam							D				
Tongue R. @ Brandenberg Br.							D*		D*		
Tongue R. @ Miles City		D						I	D*		
Hanging Woman Cr nr Birney								D*			
Otter Creek @ Ashland						D*	D*		D*		

LEGEND

I Improving Trend

D Degrading Trend

* Parameter Concentrations are at critical levels

Experience has shown that diatom diversities usually run somewhat higher than macroinvertebrate diversities. This is probably because it is more difficult to collect representative macroinvertebrate samples, particularly in large rivers, and because insects are rarely identified to species whereas diatoms are always enumerated at the species level and often at the varietal level. It should be kept in mind that these diversity values reflect only the water quality conditions required to sustain these two biological communities; they may not reflect specific water quality requirements of fish and most definitely do not reflect habitat requirements of fish. However, without sufficient water quality to protect the algae and macroinvertebrate populations upon which fish depend for survival, there would be no fishery.

Mean diatom, macroinvertebrate, and overall biological diversity values and the genral water quality conditions they reflect are presented in Table 44. These "baseline" conditions will be updated with collections to be made in 1980 and in subsequent even-numbered years. Consequently, it will be possible to begin biological trend analyses with the 1982 305(b) report.

At those stations where both diatom and macroinvertebrate diversity values are available, mean overall diversity indicated fair to good water quality. Diatom analyses are not complete for the eastern loop stations, hence water quality conditions are tenetative and based on seasonal mean macroinvertebrate diversity alone.

Table 44. Mean seasonal diatom, macroinvertebrate and overall biological diversity at stations in the State of Montana biological monitoring network.

SOUTHWEST LOOP	Mean Diatom $\bar{d}$	Mean macroin-vertebrate $\bar{d}$	Overall Mean $\bar{d}$	Water Quality
Beaverhead River at Twin Bridges	3.93	2.56	3.24	Good
Big hole River near Twin Bridges	3.75	3.07	3.41	Good
Boulder River below Boulder	3.24	3.09	3.16	Good
Clark Fork River at Deer Lodge	3.00	2.44	2.72	Fair
East Gallatin River near Belgrade	4.00	2.84	3.42	Good
Grasshopper Greek near mouth near Dillon	4.20	3.00	3.60	Good
Jefferson River near Three Forks	4.46	2.66	3.56	Good
Madison River near Three Forks	4.00	2.91	3.46	Good
Muddy Creek at mouth near Dell	3.22	2.40	2.81	Fair
Prickly Pear Creek at East Helena	3.15	3.03	3.09	Good
Prickly Pear Creek near mouth	2.77	2.82	2.80	Fair
Red Rock River above Lima Reservoir	4.98	2.38	3.68	Good
Ruby River near Twin Bridges	3.63	3.13	3.38	Good
Sheep Creek above Muddy Creek	3.86	3.40	3.63	Good
Silver Bow Creek below Warm Springs Ponds	3.11	1.98	2.54	Fair
West Fork Madison River near mouth	4.05	3.66	3.86	Good
West Gallatin River at Central Park (I90)	4.19	3.17	3.68	Good
NORTHCENTRAL LOOP				
Big Sandy Creek near mouth	4.42	0.54	2.48	Fair
Dearborn River near mouth	3.75	3.20	3.48	Good
Lodge Creek near Chinook	4.53	--	--	Excellent
Marias River near Shelby	3.28	2.62	2.95	Fair
Marias River at Loma	2.99	2.84	2.92	Fair
Milk River at Havre	3.33	2.46	2.90	Fair
Milk River above Chinook	3.92	2.02	2.97	Fair
Missouri River at Cascade	3.42	2.52	2.97	Fair
Missouri River at Fort Benton	4.18	1.22	2.70	Fair
Muddy Creek near mouth at Vaughn	3.45	2.75	3.10	Good
Pondera Creek near mouth near Chester	2.79	1.92	2.36	Fair
Smith River near Ulm	4.02	2.34	3.18	Good
Sun River near Fort Shaw	3.87	2.84	3.36	Good
Sun River below Vaughn	4.56	1.64	3.10	Good
Teton River near Dutton	4.08	2.18	3.13	Good
Teton River near Fort Benton	3.50	1.56	2.53	Fair
NORTHWEST LOOP				
Bitterroot River near mouth	3.53	3.27	3.40	Good
Clark Fork River below Bonner Dam	4.50	2.60	3.55	Good
Clark Fork River at Huson RR Bridge	4.65	3.37	4.01	Excellent
Clearwater River near mouth	4.31	3.26	3.78	Good
Fisher River at mouth	3.75	3.17	3.46	Good
Flathead River near Kalispell	3.51	2.51	3.01	Good
Flathead River near mouth	4.75	2.27	3.51	Good

Northwest Loop (Continued)	Mean Diatom $\bar{d}$	Mean macroinvertbrate $\bar{d}$	Overall Mean $\bar{d}$	Water Quality
Lake Creek near mouth near Troy	3.62	3.40	3.51	Good
Little Blackfoot River at Avon	4.73	3.24	3.98	Good
Middle Fork Flathead River near mouth	3.47	3.60	3.54	Good
North Fork Flathead River near mouth	3.29	3.41	3.35	Good
Stillwater River near mouth at Kalispell	3.82	3.27	3.54	Good
Swan River near mouth	4.21	2.80	3.50	Good
Swiftcurrent Creek near Babb	3.31	2.11	2.71	Fair
Whitefish River near mouth near Kalispell	4.22	3.39	3.80	Good
Yaak River near mouth	3.17	3.31	3.24	Good
*NORTHEAST LOOP				
Beaver Creek near Hinsdale at Beaverton		2.35		Fair
Box Elder Creek near Winnett		2.34		Fair
Big Muddy Creek near mouth near Culbertson		0.78		Poor
Big Spring Creek below Lewistown		3.14		Good
Judith River near Utica		3.30		Good
Judith River near Danvers		2.62		Good
Judith River near mouth		2.67		Good
Milk River at Nashua		0		Poor
Missouri River below Judith River		2.88		Good
Missouri River at Fred Robinson Bridge		1.85		Fair
Missouri River at Culbertson		0		Poor
Musselshell River at Harlowton		3.06		Good
Musselshell River above Roundup at Bundy		2.69		Good
Musselshell River below Roundup at Delphia		2.80		Good
Musselshell River at Mosby		2.49		Fair
Poplar River at mouth at Poplar		1.37		Poor
Redwater River at Circle		1.41		Poor
Redwater River near mouth		1.70		Fair
Wolf Creek at Stanford		2.34		Fair
Wolf Creek at Denton		2.31		Fair
*SOUTHEAST LOOP				
Armell's Creek (East Fork) near Colstrip		0.99		Poor
Beaver Creek at Wibaux		2.22		Fair
Bighorn River at Bighorn		3.44		Good
Clark's Fork River near Laurel at Edgar		2.71		Good
Little Missouri River at Capitol		1.95		Fair
Powder River at Broadus		1.35		Poor
Powder River near Miles City at Locate		0.83		Poor
Rosebud Creek near Colstrip		1.92		Fair
Shields River near mouth		3.13		Good
Tongue River at Brandenberg		2.81		Good
Tongue River at Miles City		2.57		Good
Yellowstone River near Livingston		3.65		Excellent
Yellowstone River at Billings		2.85		Good
Yellowstone River near Huntley		2.94		Good
Yellowstone River at Forsyth		2.15		Fair
Yellowstone River near Sidney		2.12		Fair

*Analyses of periphyton samples were not complete at press time; water quality assessments are tentative.

D. Lakes

There has been no systematic state program to assess the water quality of lakes in Montana. The 1977 EPA National Eutrophication Survey included 15 Montana lakes. The water quality of some lakes has been investigated by other agencies, primarily by academic institutions. However, most of these investigations have dealt with lakes which were included in the EPA survey. Even in the case of these 15 lakes the data base does not cover a long enough period of time (or include enough detail) to permit an assessment of water quality trends.

In general, Montana lakes do not receive direct point source discharges so natural conditions or nonpoint source pollution are responsible for those lakes which have poor water quality now or are degrading.

An EPA funded statewide lake inventory is now being conducted to develop baseline information from which future water quality trends can be obtained.

Two lakes (Georgetown and Sacajawea) have been funded in FY 1980 for upgrading under the EPA Clean Lakes program.

IV. Special Water Quality Problems

A. Groundwater

The Montana Water Quality Act defines State waters to include groundwater, thereby providing for establishment of groundwater quality standards and permit discharge requirements. In response to rapidly increasing pressures for development of in situ mining operations and for control of other identified surface wastewater impoundments, the Department of Health and Environmental Sciences has initiated a program to develop such standards and permit requirements.

The Department has established regulations specifically for aquifer protection during the in situ solution mining of uranium. This area promises to present a sizeable workload for the Water Quality Bureau and has potential groundwater quality impacts. There are currently about 17 companies exploring for uranium statewide. Public interest and concern about potential water quality degradation is quite high, but with the current energy shortage, pressure for development is also high.

The Water Quality Bureau is currently developing regulations for protection of shallow aquifers from seepage and infiltration of pollution from the surface. Existence of potential pollution sources is widespread, from sewage lagoons and infiltration systems to tailings and industrial process ponds. The Water Quality Bureau has been ordered by the Board of Health and Environmental Sciences to have these regulations, along with groundwater quality standards, promulgated by December 31, 1981.

A pits and ponds survey just completed at the end of 1979 shows there are at least 676 sites with waste impoundments now existing in the state. The majority of these impoundments are less than 10 years old. The push for energy and mineral development will put increasing pressure on the Water Quality Bureau to guard against potential groundwater degradation associated with the rapidly growing number of impoundments.

A random sample of ponds assessed in the report showed that only a small percentage of the impoundments are known to be lined, and very few have groundwater monitoring wells. Very few have been reported to have affected drinking water supplies, and the review showed claims not substantiated by direct evidence. Rather, they are claims of potential pollution based on the assumption that wastewater which seeps into the ground necessarily pollutes groundwater.

Results of the groundwater contamination potential assessment indicate that (1) industrial and mining impoundments tend to be located on low ground near streams where alluvial sand and gravel is present in the subsurface, and where groundwater beneath the impoundments is estimated to be moving toward the stream with no intervening water wells, (2) a very high proportion of oil and gas impoundments are located far from large streams and on glacial till or fine grainedd sedimentary bedrock where water table aquifers and shallow bedrock aquifers are not present, (3) a large proportion of impoundments in all categories

other than oil and gas tend to be located on alluvium near streams or on gravel covering the surfaces of stream-cut terraces along the major river valleys, (4) most of the impoundments are associated with water that is a current drinking water source, and (5) most of the wastewater that is put into the impoundments is associated with low to medium health hazard potential.

To date, it appears that surface wastewater impoundments have had minimal impact on the quality of groundwater in the State of Montana. However, more instances of groundwater pollution might occur in the future as more impoundments are constructed, more water wells are constructed near impoundments, and plumes of contaminated water have had more time to spread.

Another aspect of the groundwater problem is contamination by individual septic tank/leach field disposal systems in rapidly developing subdivision areas. As part of the Statewide 208 program, a contract was developed to investigate eight such subdivision/groundwater study areas in the Five Valleys area near Missoula. The study showed that there are existing or potential groundwater quality problems in at least three areas.

1. Seely Lake - Sampling and analysis has revealed a general pattern of elevated nitrate levels down-gradient from housing developments. Mid to late summer increases in total coliform counts suggest a general bacterial contamination of groundwater in the study area. However, local hydrologic and biologic factors may also be affecting this contamination. Most of the sampled wells show some form of bacterial contamination in excess of drinking water standards.

2. Florence - Geologic/hydrologic data indicate that point source discharges probably contribute to the degradation of groundwater quality in Florence. However, overall groundwater quality is generally fair to good. Although total coliforms, fecal coliforms and fecal streptococcus concentrations were detected in wells sampled in late June, there was no contamination during the September sampling period. Nitrate levels were well below the safe limits.

3. Rattlesnake - Nitrate concentrations were found at elevated levels in most wells tested, both in confined and semi confined aquifers. Sources of nitrate concentrations appear to be individual septic systems, animal wastes and irrigation return flows. Bacteriological contamination was also apparent in some wells.

The Libby area also has a very significant groundwater problem in nearby South Libby Flats, which has experienced rapid, uncontrolled growth. Groundwater serves as the water supply for approximately 2000 people and the contamination is extensive enough to cause an imminent threat to public health. Tests have revealed concentrations of nitrates above the drinking water standard, and fecal coliform contamination has also been detected.

Another current significant groundwater issue concerns a petition for sole source designation of a portion of the Helena Valley Shallow Aquifer. Several public water supply systems are served by the aquifer which may be affected by increased subdivision activity, mining and the installation of a petroleum pipeline. Another concern is the possibility of contamination from the injection of raw sewage sludge in the proposed sole source area. The petition is currently in the review process.

B. Saline Seep

Saline seep, or north slope alkali as it was once known, is caused by the widely-accepted dryland farming practice of summer fallowing every other year. Saline seep first began appearing on the Highwood Bench south of Fort Benton during the 1950's and has rapidly spread to many other areas of the state. The area affected by saline seep in Montana has been estimated by various sources to be from 140,000 to 200,000 acres. The Montana Association of Conservation Districts, through a survey conducted as part of the Statewide 208-AgNPS assessment, estimates that 164,000 acres are affected by saline seep in the 42 county statewide 208 area alone, (see Table 45), which does not include much of the southcentral and southeastern parts of the state. Most authorities agree with estimates that saline seep is increasing at somewhere near ten percent per year.

Saline seep has appeared relatively recently, approximately 50-60 years after dryland farming became widespread in the state. Considering the fact that about 11 million acres of dry cropland is found within the statewide 208 area and saline seep is rapidly increasing, the potential impact to our ground and surface water resources may be quite great. From previous work done by the Montana Bureau of Mines and Geology and the Water Quality Bureau, it is clear that waters produced by saline seeps are usually extremely salinized (up to 2-3 times greater than sea water); they may contain high concentrations of nitrates which can be toxic to man and livestock; and they sometimes contain high levels of trace metals, such as selenium, which can produce many harmful effects. These past studies have been directed largely to determine ground water elevation fluctuations and towards analysis of the seep water to determine its makeup. Existing data is not adequate to determine the overall effect that saline seep development may be having on the ground water, although there are reports of domestic wells going "sour" and becoming unfit for use within several saline seep areas. Surface water quality may be suffering as a result of seepage of salinized water into our lakes and streams. Interest in installing subsurface drains to reclaim saline seeps appears to be gaining momentum throughout the state. If this highly salinized water empties into a live drainage, the potential for impairment of water quality for downstream water users certainly exists. The Water Quality Bureau now requires a discharge permit for such drains and issues permits only when the proposed discharge will not degrade existing water quality based on the Departments nondegradation policy.

In order to obtain better information about the existing and potential threats from saline seep, the Water Quality Bureau is supporting investigations by the Montana Bureau of Mines. These investigations are resulting in the collection and analysis of hundreds of samples from wells and springs throughout the problem areas, and an evaluation of existing saline seep drains on receiving stream quality.

TABLE 45

ACREAGE AFFECTED BY SALINITY IN THE STATEWIDE 208 STUDY AREA

Basin	Irrigated Acres	Cropland Trend	Dry Acres	Cropland Trend
Kootenai	0	-	0	-
Clark Fork	2,850	same	6,714	same
Jefferson	21,675	same	150	same
Madison	0	-	0	-
Upper Yellowstone	350	same	0	-
Upper Missouri	18,585	variable	26,860	increase
Marias	2,800	increase	20,929	increase
Middle Missouri	1,061	variable	37,619	increase
Musselshell	2,630	increase	12,682	increase
Milk	7,225	increase	14,960	increase
Lower Missouri	506	variable	37,230	increase
Lower Yellowstone	340	variable	3,271	increase
Lower Tongue	0	-	4,000	increase
Beaver	0	-	5	same
	58,022		164,420	

TABLE 46

MILES OF DEWATERED STREAM SEGMENTS IN THE STATEWIDE 208 STUDY AREA

Basin	Miles Dewatered
Kootenai	4
Clark Fork	155
Jefferson	41
Madison	0
Upper Yellowstone	32
Upper Missouri	55
Marias	67
Middle Missouri	135
Musselshell	224
Milk	160
Lower Missouri	0
Lower Yellowstone	0
Lower Tongue	0
Beaver	0
	873

C. Dewatering

All streams in Montana are dewatered, that is, a certain amount of water is removed from every stream for one or more beneficial uses. By strict definition, dewatering itself is not pollution, but in many cases reduced flows do contribute to water quality degradation and so deserve attention from a nonpoint source management aspect.

The major effects of dewatering are reduction of the stream's dilution capacity and biotic habitat. In extreme cases, the stream channel may become totally dry. With reduced flows salt concentrations and temperature increase and oxygen levels drop. These conditions may be toxic or inhibitory to fish and other aquatic life and reduce water quality for other beneficial uses. The problem may be compounded by additional pollutant loads, which the stream can no longer assimilate adequately.

The degree to which a stream's quality is degraded by dewatering depends on several factors: pre-existing water level and quality, total amount of water removed, duration of reduced flows, time of year, and the social, economic, and environmental value of the stream prior to dewatering. The problem is often a subtle one, particularly on larger streams where significant amounts of water can be removed without apparent effects.

Although dewatering has been critical in the Clark Fork, Beaverhead, Bitterroot, West Gallatin, Big Hole, and Jefferson Rivers, many other stream segments are frequently affected. A questionnaire completed by the states's Conservation Districts has helped to more accurately identify the extent of the dewatering problem. Any consumptive beneficial use can potentially dewater a stream to the point that its quality is impaired. However, irrigation accounts for more than 95 percent of the water withdrawn from streams in Montana.

Some of the most obvious and critical dewatering problems were identified by the Conservation Districts. The questionnaire defined dewatering as follows: Either 1) the stream is actually or for all practical purposes, dry; 2) the stream is reduced to a series of separated pools; or 3) significant portions of the streambed, which would otherwise be under water, are exposed. Dewatered segments identified by the Districts totalled 873 miles in the statewide 208 area. Stream miles dewatered are aggregated by basin in Table 46.

The Blue Ribbons 208 Study in 1977 also identified several stream segments which were completely dewatered. They included Cottonwood Creek (AG26) during the sampling run of July 27, 1977, Hyalite Creek (AG15) following the last sampling run of July 27, 1977, and the Gallatin River below Irving Bridge, west from Belgrade, for a distance of approximately four miles on July 21, 1977. It is estimated that this section of the Gallatin River remained dry for five days.

Other stream segments which were almost completely dewatered during the course of the study are displayed below by location, station number and date.

D. Drinking Water

The initial Montana law relating to public water supplies was originally enacted in 1907. This law was revised in 1977 and again in 1979 to enable Montana to receive and retain delegation for administration of the "Federal Safe Drinking Water Act" (PL 93-523) enacted in 1974. Montana's program covered about 250 community water systems prior to 1978. The present program regulates all systems which have at least 10 service connections or serve at least 25 individuals daily for at least 60 days a year.

The current inventory, as submitted to EPA on January 1, 1980, listed 609 community water systems and 1,147 non-community water systems. The following table presents the information available from the inventory for the community water systems:

TABLE 47

Summary of Community Water Systems in Montana

Surface Water Systems:	No. of Water Systems	Population Served
10,000 - 75,000 population	7	290,000
1,000 - 10,000 population	31	93,000
100 - 1,000 population	17	9,000
25 - 100 population	6	600
Total	61	392,000
Ground Water Systems:		
10,000 - 75,000 population	2	22,000
1,000 - 10,000 population	32	69,000
100 - 1,000 population	190	56,000
25 - 100 population	316	14,000
Total	540	161,000
Consecutive Water Systems:		
10,000 - 75,000 population	0	0
1,000 - 10,000 population	7	13,000
100 - 1,000 population	0	0
25 - 100 population	0	0
Total	7	13,000

The surface water systems consist of water systems that provide water completely or in part from surface sources. Consecutive water systems are ones that purchase all of their water from other water systems and do not have any sources of their own.

The table presents a number of interesting items, for example:

1. The largest community water system in Montana serves a population of 72,000 (based on the 1970 census). It is anticipated that the population figure will be higher at the completion of the 1980 census.

2. Only one percent of Montana's community water systems serve more than 10,000 persons - the population used in early EPA estimates of water system capability to fund standard treatment for removal of regulated contaminants. However, this one percent of the systems serves 55 percent of the people who obtain water from a public water system. The "small system strategy" currently under development by EPA will impact over 99 percent of Montana community water systems.

3. Fully 87 percent of Montana community water systems serve fewer than 1,000 persons. This 87 percent of the systems provides water to only 14 percent of the population obtaining water from a public water system.

4. Ten percent of all community systems are surface water. The systems supply water to 70 percent of the population. More than 88 percent use ground water. One percent purchases water from another water system.

From a quality standpoint, Montana's drinking water is considered generally good in the western part. Those supplies in the eastern part, particulary groundwater, would be considered poor. The exception in the western part are the surface supplies which are high in turbidity. In the eastern part of the state, the communities using surface supplies with few exceptions, have water treatment facilities capable of providing quality water. However, the groundwater supplies are generally high in total dissolved solids. Some of the smaller supplies have fluorides and nitrates which exceed the MCL. Table ___ identifies on a statewide basis the fluoride, nitrate, arsenic, sel nium and turbidity problems in the state.

Table 48

Community Public Water Supplies Which Exceed MCL's

Supply	Constituent	Reported Level (mg/l)	Maximum Contaminent Level (MCL)
Ashland	Fluoride	3.9	2.4
Circle		5.2	
Lambert		4.1	
Richey		4.4	
Highland Park, Glendive		3.8	
Spring Grove Tr. Ct		3.1	
Cheeks Tr. Ct.		3.8	
Alta Tr. Ct. Miles City		2.57	
Bills Trailer Ville		2.74	
Greenstar Mob. Hm Village		2.96	
Wagon Wheel Tr. Ct.		2.58	
W&R Mob. Hm Village Fairview		5.23	
Wagon Wheel Tr. Ct. Forsyth		5.5	

Supply	Constituent	Reported Level (mg/l)	Maximum Contaminent Level (MCL)
Flaxville	Nitrate	34.0	10.0 as NO_3-N
Rapelje		13.0	
Coffee Creek		14.0	
Denton		13.0	
Three Forks	Arsenic	0.06	0.05
Rapelje	Selenium	0.036	0.01

Community Public Water Supplies which utilize surface water and have exceeded the maximum contaminant level of 1.0 N.T.U. for a monthly average.

Culbertson
Bozeman
Canyon Ferry
Devon
Tiber County Water District, Conrad
Fort Peck
Rainbow Dam
Ryan Dam
Harlem
Helena (Ten Mile System)
Neihart
Ronan
White Sulphur Springs

Community Public Water Supplies which use surface water and do not monitor turbidity

East Glacier
Hill County Water District, Hingham
Power
St. Ingatius
Sheridan
Tory

Nearly all of the community public water supplies are now monitoring for bacteriological quality on a regular basis and the maximum contaminate levels for coliform bacteria are rarely exceeded. Of 576 community supplies only about 15 have not yet begun a regular bacteriological monitoring program.

The inventory of noncommunity public water supplies was completed at the end of 1979 and about 40% of these supplies have begun taking bacteriological samples on a quarterly basis.

A program for radiological monitoring is now being developed and will be implemented over the next 1-2 years. This program is planned to include all community supplies.

E. Fish Kills

TABLE 49

Summary of Recent Major Fish Kills in Montana*

Date	Location	Cause	Extent and Number Killed
5/3-6/76	Madison River Madison Co. near Ennis	Industrial, hydroelectric facility, high temperatures & super saturation	5 river miles heavy mortality 15,000 fish, 30% game, brown trout, mountain whitefish
3/3-4/77	Silver Creek Lewis & Clark Co. near Helena	Industrial, mining, cyanide	4 creek miles total mortality 3,500 fish, 80% game, westslope cutthroat trout
4/28/79	Madison River Madison Co. near Ennis	Unknown, believed to be related to the hydroelectric facility	1/2 river mile light mortality 1,000 fish, 15% game, brown trout, Utah chub, mountain whitefish
7/19/79	Mill Creek Missoula Co. near Frenchtown	Agricultural, aquatic herbicides (xylene)	1 creek mile heavy mortality 5,000 fish, 60% game, brown trout, rainbow trout, mountain whitefish
7/17/79	Beaverhead River Madison Co. near Twin Bridges	Agricultural, aquatic herbicides (Acrolein)	3 river miles heavy mortality 20,000 fish, 25% game, brown trout, mountain whitefish, Sculpin
7/13/79	Blacktail Deer Creek Beaverhead Co. near Dillon	Agricultural, dewatering and aquatic herbicides	1 creek mile heavy mortality 1,000 fish, 20% game, brown trout, Sculpin
9/3/79	Mill Creek Madison Co. near Sheridan	Agricultural, aquatic herbicides (Acrolein)	1.5 creek miles heavy mortality 3,000 fish, 70% game, brown trout, brook trout
9/12/79	Billman Creek Park Co. near Livingston	Agricultural, weed spraying 2,4-D ester	1.5 creek miles 1,500 fish, 30% game, brown trout, Sculpin

* Prepared by Mr. Ken Knudson, Pollution Biologist for the Montana Department of Fish, Wildlife and Parks.

F. Ammonia

Un-ionized ammonia has been identified as having a toxic effect on aquatic organisms. The toxic, un-ionized fraction is directly related to water temperature and pH. Municipal sewage treatment systems, whether lagoons or treatment plants, contain a significant amount of ammonia in their effluent. For this reason, those municipalities that have a discharge to state waters were considered potential sources of toxic un-ionized ammonia.

Flow, pH, temperature and ammonia data often are not available for municipal discharges and receiving waters. In the absence of actual data, the possibility of an ammonia toxicity problem associated with each municipal discharge was evaluated through a series of calculations using typical values for the discharge and receiving water. For those municipalities that were placed in the potential problem category (Table 50), lack of real data made it impossible to impose specific ammonia limitations. Instead, intensive surveys are being done to demonstrate whether a toxic ammonia effect from the sewage treatment facility actually exists. If a problem does exist, data from the survey will allow establishment of reasonable and justified ammonia limits for the protection of fish and other aquatic life.

Of the forty-five municipalities identified as having potential ammonia problems, sufficient data have been collected to demonstrate that nine have no problem (Chester, Columbia Falls, Denton, Geraldine, Glasgow, Hamilton, Libby, Brady and Warm Springs) and to establish limits for one (Bozeman). A preliminary survey for Missoula was inconclusive and a more intensive followup survey is scheduled for 1980.

Table 50 - Municipal sewage treatment systems and receiving waters identified as having a possible ammonia toxicity problem.

MUNICIPALITIES	RECEIVING WATER
Belt	Belt Creek
Big Sandy	Big Sandy Creek
Boulder	Boulder River
Bozeman	East Gallatin River
Browning	Depot Creek - Willow Creek
Butte	Silver Bow Creek
Chester	Cottonwood Creek
Chinook	Milk River
Choteau	Teton River
Circle	Redwater River
Columbia Falls	Flathead River
Conrad	Dry Fork, Marias River
Cut Bank	Old Maids Coulee - Cut Bank Creek
Denton	Wolf Creek
Dillon	Beaverhead River
Dodson	Dodson Creek
Geraldine	Flat Creek
Gildford	Sage Creek
Glasgow	Milk River
Hamilton	Bitterroot River
Harlowton	Musselshell River
Havre	Milk River
Helena	Prickly Pear Creek
Highwood	Highwood Creek
Hillbrook Nursing Home	Prickly Pear
Joliet	Rock Creek
Kalispell	Ashley Creek
Lavina	Musselshell River
Lewistown	Spring River
Libby	Kootenai River
Missoula	Clark Fork
Missoula County - Lolo	Bitterroot River
Philipsburg	Flint Creek
Plentywood	Big Muddy Creek
Brady (Pondera Co.)	South Pondera Coulee
Red Lodge	Rock Creek
Ronan	Crow Creek
Shelby	Old Maids Coulee
St. Ignatius	Mission Creed - Matt Creek
Sheridan	Mill Creek
Stanford	Coyote Creek
Warm Springs	Clark Fork River
White Sulphur Springs	Hot Springs Creek
Wibaux	Beaver Creek
Winnett	McDonald Creek

G. Energy Development

Montana is nationally known for its vast fishery resources and high quality waters and also for its tremendous energy reserves. The potential for conflict between these resources is not difficult to imagine. The national energy supply problem is becoming more critical by the day--not only in terms of meeting present needs but also long term availability and cost stability. With the western states containing much of the nation's energy reserves, this region is looked to for the bulk of the increase in domestic energy production. A dramatic increase in domestic energy production will have severe social and environmental impacts where that energy is extracted, produced and refined.

Montana contains potential reserves of gas and oil in the overthrust belt; an abundance of free flowing, high gradient rivers; uranium potential just beginning to be realized; and at least 43 billion tons of economically-strippable coal. Those concerned with Montana's natural resources have reason to look apprehensively toward the future.

The list of possible water quality and fishery impacts in Montana is long and tedious. To put the various solutions to the energy crunch in proper perspective, the effects on air, land and water from various kinds of energy development must be addressed.

The major energy resources likely to be developed in Montana are coal, hydropower, gas, oil and uranium. While a modest degree of development of any one of these energy sources could probably be accommodated with minimal environmental disruption, the degree of development needed to make a significant contribution to the country's energy shortfall could cause significant environmental degradation. Development of coal and hydropower resources is likely to produce the most severe and long term impacts, with oil and gas development running close behind.

The following is an examination of each major energy source with a list of significant projects that could have adverse water quality and fishery impacts.

1. Coal

The southeastern portion of Montana, northeastern Wyoming and western North Dakota contain the Fort Union coal formation. In Montana, scattered coal deposits can be found in other locations. Coal has been promoted as the major interim fuel source, a possible way out of the energy crisis and one of the most important energy reserves. In any national energy policy, coal is likely to play a key role. The development of Montana's coal reserves can take two forms: First, and currently most common, Montana coal is mined and exported to power plants outside the state. Or, Montana coal could be mined and converted to various forms of energy within the state.

The adverse environmental impacts associated with strip mining and transportation of coal have been well documented. The physical disruption to wildlife habitat during the mining operation; impacts associated with haul roads, railroad spur lines, vehicular traffic and dust; ground water table disruption and surface runoff; new communities; and problems with adequate reclamation have been discussed extensively. Significantly accelerating coal mining, whether for export or on-site conversion, would increase the occurrence of those impacts.

The on-site conversion of coal to more usable forms of energy also looms prominently on the Montana horizon. In the past, the principal coal conversion facility considered was the coal-fired electric generating plant. Now, however, the prospect of coal gasification or the production of pipeline quality gas and synthetic fuel ("synfuel") appear as real possibilities in energy production. Fish and wildlife impacts from such on-site conversion facilities have far more widespread implications than simply the mining of coal. Generally, the more complex the energy facility becomes, the greater and more diverse the impacts on fish and wildlife.

The greatest impact is likely to come from synthetic fuel plants. From the little that is known of them, synthetic fuel plants cover significant quantities of ground; a 60,000-barrel-per-day plant requires up to four square miles of land, if the plant currently operating in South Africa is any indication. In addition, a large companion power plant is necessary to provide energy for the synfuel plant and a separate coal mine is needed to supply the coal. Branching out from the plant boundaries itself, stack emissions from the power plant and the synfuel facility would adversely affect habitat and vegetation in downwind areas. The copious quantities of water necessary to cool the generating plant and to process the coal into products would come from nearby water sources. In semiarid southeastern Montana, additional water diversions during critically dry periods would have significant adverse impacts reaching far beyond the fish and wildlife resource. Severe competition for an already limited water resource would be ensured. Existing water users would have a new consideration to deal with when drought years rolled around. Aquatic impacts, particularly on the smaller tributary streams of the Yellowstone, could be severe.

Table 51 and Table 52, respectively, indicate the anticipated new coal mines and potential coal related energy production facilities that may be developed in Montana in the relatively near future.

Table 51

Anticipated New Coal Mines

Applicant Company	Mine	County	Permit Application Date	Applicant's Proposed Opening Date	Estimated Maximum Production Per Year* (million tons per year)
Shell Oil Company	Pearl	Big Horn	1/20/78	1980	2
Montco	Nance	Rosebud	anticipated	1983	12
Burlington Northern	Circle West	McCone	anticipated	1982	6
Consol	CX Ranch	Big Horn	anticipated	1982-83	4
Peter Kiewit Sons	Squirrel Creek	Big Horn	anticipated	1982-83	4
Louisiana Land and Exploration	-	Musselshell	anticipated	1982	2
Western Energy	-	Custer	anticipated	-	-

Source: Montana Department of State Lands

*Mines typically do not reach maximum rates of production until the third or fourth year after opening.

Table 52

Potential Coal-Related Energy Production Facilities in Montana

Potential Electric Generating Plants

Company	Size	Location
Basin Electric	1000 MW	Circle , MT., or Gillette, Arvada, Wyoming
Montana Power Company	350 MW +350 MW	Chester, Hardin, Great Falls

Potential Coal Gasification/Liquifaction Plants

Tenneco Co.	250 mm ft^3 of natural gas & 880 MW coal fired power plant	Wibaux County
Montana Power Company	tentative	unknown
Washington Energy Co.	250 mm ft^3	McCone County
Utah International	Several plants each of 250 mm ft^3	Powder River County
Burlington Northern	100,000 barrels of crude oil	Glendive
Northern Resources	6 million tons of coal per year to produce fertilizer and methanol-diesel	McCone County
DOE (feasibility)	14 mm ft^3	Billings

2. Hydropower

In July, 1979, the U.S. Army Corps of Engineers released a preliminary inventory of hydropower resources in the United States. The inventory is part of the "National Hydroelectric Power Study," authorized by Section 167 of the Water Resources Development Act of 1976 (P.L. 94-587). The study is designed to provide a current and comprehensive estimate of the potential for incremental or new generation at existing dams and other water resources projects, as well as for undeveloped sites. The National Hydropower Study also addresses the demand for hydroelectric power, and investigates various related policy and technical considerations to determine the incentives, constraints and impacts of developing hydropower to meet a portion of the nation's future energy demands. The National Hydropower Study will be completed in 1981.

In the "Preliminary Inventory of Hydropower Resources" for the Mid-Continent Region, the Army Corps of Engineers identified 222 sites in Montana where new or additional hydroelectric facilities could be located. The sites included creeks, canals, and rivers in 40 of the state's 56 counties. According to the Army Corp's figures there are: (1) 20 existing hydroelectric power facilities currently generating power in Montana with 2,418 MW total capacity; (2) 88 existing dams and/or other water resource projects with the potential for 2,332 MW new and/or additional hydroelectric capacity; and (3) 134 undeveloped sites where no dam or other engineering structure presently exists with a potential of 15,313 MW capacity.

The development of additional hydroelectric power on the states waterways is a very real threat.

Montana is blessed with an abundance of rivers--some are free-flowing and many still have a good portion of their length unimpounded. Since most have their headwaters in Montana, the gradients are relatively high. The combination of flowing water and high gradient makes most of the river inescapably appealing for impoundment (damming) and hydroelectric power generation.

Several of Montana's rivers are being seriously considered for additional hydropower facilities. Table 53 identifies potential hydropower facilities which have been or are being considered for development in Montana. While biologists commonly analyze river resources in terms of fishermen days of use, pounds of brown trout per 1,000 feet of stream or number of floaters per day, the U.S. Army Corps of Engineers (in a July 1979 inventory of the state's hydropower potential) refers to rivers in terms of megawatts of electricity, hydropower potential and power peaking capabilities. That particular study reidentified such controversial dam sites as Allenspur on the Yellowstone, Reichle on the Big Hole, Spruce Park and Glacier View on the North Fork of the Flathead, five on the Big Blackfoot and many, many more.

Increasing hydropower production in Montana can take one of three forms, or a combination: (1) constructing new dams, (2) converting existing facilities from baseload to power peaking generation or (3) adding hydropower to existing dams. The impact from any one of these methods depends on the magnitude and location of the project.

Table 53

Potential Hydropower Facilities in Montana

Facility	Location
Fort Benton New earthfill dam and hydropower plant	Missouri River below Fort Benton
Canyon Ferry New 90 MW peaking facility	Missouri River at Canyon Ferry
Fort Peck Dam New 125 MW power plant and reregulation dam	Missouri River at Fort Peck
Montana Power Company Additional power capacity at four existing sites	Hauser on the Missouri, Ryan on the Missouri, Kerr Dam on the Flathead, Thompson Falls on the Clark Fork
Northern Lights New 150 MW power plant	Kootenai Falls
Libby Reregulate Dam and additional generation at Libby Dam (no authorizations from congress)	Kootenai River
Yellowtail Afterbay New power plant 114 MW	Yellowtail on the Bighorn River two miles below existing power plant
Gibson Dam New hydropower facility	Sun River
Tiber Dam New hydropower facility	Marias River
Clark Canyon Dam New 3.5 MW power plant	Beaverhead River 18 miles southwest of Dillon

Basically, construction of new dams on free-flowing reaches of river tends to devastate the river ecosystem. The reservoir floods the existing river, bottomland wildlife habitat and the prime agricultural land beneath it. In addition, impounding waters behind dams generally alters the natural flow regime downstream from the dam. Sediment trapped behind the dam alters hydrologic characteristics downstream and, depending on the outlet structure, the water released from the dam may affect downstream water temperatures. Examples of new dam projects proposed for Montana rivers include the Northern Lights' hydroelectric project at Kootenai Falls and the Water and Power Resources Service's (formerly the Bureau of Reclamation) proposed dam on the Missouri River at or above Fort Benton.

The second type of hydropower project which can impact aquatic resources is the conversion of a baseload generating dam to power peaking. Baseload generation is the daily, steady or constant generation of electricity; it requires a steady release of water from the dam. The fish and aquatic insect populations below baseload hydropower dams adapt to the steady release and the quality of the recreational fishery remains basically unchanged. Power peaking, on the other hand, is the generation of large quantities of electricity during peak load hours. A power peaking facility may generate large quantities of electricity for eight hours a day and be completely shut off for 16 hours. This means the dam would release large quantities of water for a limited period during the day but would be shut off for the remainder.

The impacts of power peaking on downstream areas can vary considerably, but they can have disastrous effects on fish reproduction in downstream areas. In general, fish move upstream during the spawning season to locate suitable spawning sites. When upstream movement is blocked by a dam, spawning often will occur just downstream from the dam. Successful trout reproduction depends on a steady flow of water over the incubating eggs. The "off" period when the facility is not generating electricity or releasing water would eliminate flow over the eggs and result in considerable, if not total, reproductive failure. In addition, the food chain could be impacted because aquatic insect communities immediately downstream also depend on flowing water.

Another major effect of power peaking is fluctuating water levels below the dam. If there is a reservoir immediately below a power peaking facility, water levels within that downstream or reregulation reservoir will be raised and lowered. Depending on the characteristics of the reregulation reservoir, the impacts may be minimal or severe. If, on the other hand, a free-flowing river exists below a power peaking facility, the downstream impacts can be disastrous. It is conceivable that the river immediately downstream would go from almost full channel flow to dry streambed in normal, daily operation. Effects on fish, wildlife and recreation under such an operating regime are obvious. When a power dam is converted from baseload generation to power peaking, there is often little or no net gain in electricity produced on an annual basis.

Many dams in the state were built solely for flood control and irrigation: the Tongue River, Clark Canyon, Tiber and Gibson Dams, for example. To add generators without changing the release patterns achieves the goal of increasing net hydropower production while at the same time not harming aquatic resources downstream.

3. Oil and Gas

The exploration for the development of oil and gas reserves in Montana is proceeding at a feverish pace. In the past, much of this activity was carried out on the plains and in foothill areas. In such terrain, it was possible (although not always accomplished) to carry out exploration work with minimal adverse environmental effects.

Spurred on by the energy crisis, the present trend is to explore deeper and deeper into the mountain areas of the state. The Rocky Mountain Front in Montana is an area of extraordinarily high fish, wildlife and wilderness values. The Sun River Wildlife Management Area, the Bob Marshall and the Gates of the Mountains Wilderness areas and many other areas are typical of the resource amenities prevalent along the east slope of the Montana Rockies. These same areas are considered crucial by the gas and oil industry.

Unlike earlier exploration in the plains and foothill areas, intrusions into mountain canyons, plateaus and hillsides cannot be done casually or unobtrusively. Roads must be built, equipment transported and testing accomplished. Much of this may happen in habitats critical to fish and wildlife and of high wilderness value. In the event that significant reserves of gas and oil are discovered in the mountainous areas, development of such reserves will not only compound the exploration impacts but introduce a new range of impacts associated with drilling, pumping, storage and transportation activities.

H. Sediment - (Muddy Creek)

Sediment, along with salinity and dewatering, is one of Montana's "big three" water quality problems. Although attempts have been made to identify lands susceptible to erosion, in only a few cases, thus far, have Conservation Districts identified specific land management practices which are causing sediment problems in streams. One of these cases, and perhaps the most important one statewide, is Muddy Creek of the Sun River.

Muddy Creek is a tributary of the Sun River, which enters the Missouri River 15 miles downstream at Great Falls, Montana. The Muddy Creek drainage located in northcentral Montana, comprises 314 square miles of which one-third is dry cropland, one-third is range and one-third is irrigated lands.

The major water quality problem is the large amount of sediment presently being discharged into the Sun and Missouri Rivers. Muddy Creek averages 213,000 tons of sediment and 90,000 acre-feet of flow annually. This provides 80 percent of the total sediment load of the Sun River and only 17 percent of the drainage area. The major sediment source is the lower portion of the Muddy Creek channel. The causes for this excess sediment load and channel erosion are the increased annual flow from an estimated natural flow of 10,000 acre-feet to 90,000 acre-feet, present land use practices, and geologic and soil characteristics conducive to excessive erosion. Present biological conditions indicate environmental stress upon the Muddy, Sun, and Missouri drainage systems.

The basic solution to the hydraulic, sediment and nutrient problems associated with Muddy Creek is the reduction of flows and erosion in the Muddy Creek channel. A set of physical component solutions are recommended. These are on-farm management, supply canal relief, an interceptor canal, and Muddy Creek channel stabilizations. A comprehensive information program is needed to generate support for increased natural resources management. Finally, adequate funding, approximately $25 million, will be required to implement these programs.

Within ten years it is felt that flows in the Muddy Creek channel can be reduced by 80 percent with a corresponding sediment load reduction of 75 percent, and nutrient load reduction of 50 percent.

In order to obtain a better understanding of existing environmental conditions in the project area, the Water Quality Bureau has initiated a water quality monitoring program to help fill existing data deficiencies In addition, the Soil Conservation Service and the Water and Power Resources Service are involved in additional investigations to better define the problem and develop feasible control programs.

V. Water Quality Goals and Control Programs

A. 1983 Goals and Attainment

The Montana Department of Fish, Wildlife and Parks (DFW&P) has developed a detailed procedure for classifying Montana streams according to their fish resource value. Each stream reach was placed in a value class for each of two criteria: 1) Habitat and Species Value and 2) Sport Fishery Potential. Value classes for each of these two criteria were assigned to a reach by a computer program. The program uses fisheries inventory data that have been recorded by fisheries biologists and entered into a computer file. The final classification--the Fishery Resource Value--was the higher class given for criterion 1 or 2 above.

Six fishery resource value classes have been established:

Class	Definition
1	Highest-valued fishery resource
2	High priority fishery resource
3	Substantial fishery resource
4	Moderate fishery resource
5	Limited fishery resource
6	Not classified

Generally, class 1 streams correspond to the so-called "blue ribbon" waters. Class 6 waters either were not inventoried for fish or are naturally unsuitable for fish because of their small size and/or intermittent discharge. Consequently, for the purposes of this report, class 5 stream reaches were designated "not fishable," presumably because of man-caused constraints, even though they may have limited fishery resources.

The total length of Montana streams in each of the top five classes is given below:

Class	Kilometers	Miles	Percent of Total
1	2,728	1,694	9.9
2	3,143	1,952	11.4
3	10,553	6,553	38.1
4	11,166	6,934	40.3
5	78	48	0.3
Total	27,668	17,181	100.0

Only 48 miles of streams, representing less than one percent of the total stream mileage in the state, are class 5 or "not fishable." These stream reaches are listed in Table 54.

Table 54. Fishery resource value class 5 stream reaches in Montana.

Stream	Tributary To	Reach	Kilometers
Little Sheep Creek	Red Rock River	road crossing to mouth	12.6
Blacktail Deer Cr.	Beaverhead R.	above E. Bench Canal	2.4
Dry Boulder Creek	Jefferson River	road crossing to mouth	8.0
Dry Creek	Boulder River	Hunting Gulch to mouth	9.7
Deep Creek	Yellowstone R.	Highway 540 to mouth	1.6
Mountain View Cr.	Stillwater R.	headwaters to mouth	3.0
Bear Springs Cr.	Fisher R.	source to mouth	9.7
Deer Creek	Fisher R.	source to mouth	6.4
Willow Creek	Blackfoot R.	Nat. Forest boundary to mouth	8.0
Mary Ronan Creek	L. Mary Ronan	source to mouth	3.2
Proctor Creek	Flathead Lake	source to Indian Reservation boundary	2.4
Cow Creek	Whitefish River	source to mouth	6.4
Lazier Creek	Thompson River	source to mouth	9.7

Conspicuously absent from this list are the five stream reaches in Montana presently classified E-F (E), a classification that does not recognize fish propagation as an existing use. (See Water Quality Standards--Appendix C.) These five reaches are listed in Table 55. Three of these five stream reaches have not been inventoried, presumably because they have been identified as low priority streams by fishery managers.

One of the five E-F (E) reaches that has been inventoried is Prickly Pear Creek below East Helena. For the purposes of the DFW&P inventory, this reach was combined with an upstream segment extending to the mouth of Clancy Creek. This upper segment is classified B-D_1 (B-1). The fishery resource value of these combined reaches is given as 3--"substantial fishery resource." Prickly Pear Creek below East Helena is classified E-F (E) primarily because it is regularly dried up by diversions during the irrigation season. However, the DFW&P listing for this reach does not identify water removal or fluctuation problems!

A similar situation prevails on Ashley Creek, where the DFW&P inventory combined the lower E-F (E) reach with a higher quality reach upstream. The combined reaches are similarly rated 3--"substantial fishery resource." These situations prompt a recommendation that DFW&P adjust their stream reaches to coincide with E-F (E) water quality classifications identified in the state water quality standards.

In any event, the total number of stream miles in Montana considered to be "not fishable" is estimated to be about 120. Of these, 48 miles have limited fishery resources and 72 miles have essentially no recognized fishery resources. Of the latter, E-F (E) waters, plans are underway to upgrade Ashley Creek, primarily by improving wastewater treatment at Kalispell. Ultimately, this will add seven more stream miles to "fishable" status.

Two of the four remaining E-F (E) streams--Muddy Creek and Prickly Pear Creek--are so classified largely because of nonpoint types of pollution and both are being addressed by the statewide 208 program and by others.

The problems with Muddy Creek are excess sediment, discharge and nutrients stemming from irrigation systems and practices. A significant effort is now underway to correct these problems. (See Chapter IV.H. Sediment--Muddy Creek.)

The problem with the lower reach of Prickly Pear Creek is primarily dewatering. The DFW&P is currently pursuing legislation in Congress to mitigate the environmental effects of transforming Canyon Ferry Dam into a power peaking facility. This "mitigation package" includes a provision to supply Missouri River water to Helena Valley water users so that lower Prickly Pear Creek will retain flows throughout the irrigation season.

Possibly the most difficult and expensive E-F (E) water quality problem to correct will be that of Silver Bow Creek. A number of pollution sources contribute to the fish-less status of Silver Bow Creek, including municipal and industrial discharges, storm drainage, and the presence of over two million cubic yards of old mine tailings in the stream's floodplain. This latter

Table 55. Stream reaches in Montana in which fish propagation is not recognized as an existing use.

Stream	Tributary To	Reach	Kilometers (est.
Prickly Pear Cr.	Missouri River	Highway 433 to mouth	16
Silver Bow Creek	Clark Fork R.	Blacktail Deer Cr. to Warm Springs Cr.	40
Ashley Creek	Flathead R.	bridge on airport road to mouth	11
Hot Springs Cr.	Little Bitterroot River	Hot Springs water supply intake to mouth	16
Muddy Creek	Sun River	source to mouth	32

source may prove to be the most stubborn obstacle to water quality reclamation in the upper Clark Fork River drainage.

The final E-F (E) classification in Montana is a 10 mile stretch of Hot Springs Creek from the town of Hot Springs water supply intake to the Little Bitterroot River. This is a fish-less water because of natural thermal conditions compounded by dewatering and municipal wastewater, and there is little immediate prospect for making it fishable. There are likely a number of other naturally thermal waters in Montana that do not support fish, but these have been overlooked or ignored in the classification process. (Also overlooked in the classification process are a large number of ephemeral streams and silt-laden streams that never supported resident fish populations in their natural state.)

In assessing existing water quality with regard to the 1983 swimmable and fishable goals of the Clean Water Act, the following streams are the only ones in the Blue Ribbons planning area that fall short:

Stream Segment	Comments
1. Bozeman Creek below Kagy Boulevard	Unswimmable based on fecal coliform concentrations and other urban runoff pollutants.
2. East Gallatin River below Bozeman STP to Dry Creek Confluence	Unswimmable based on fecal coliform concentrations.
3. Godfrey Creek	Unswimmable based on fecal coliform concentrations.
4. Camp Creek	Unswimmable based on fecal coliform concentrations.
5. Elk Creek	Unswimmable based on fecal coliform concentrations.
6. Dry Creek	Unswimmable based on fecal coliform concentrations.
7. Cement Creek	No propagation of salmonoid fishes due to sediment.
8. Yellow Dog Creek east of Churchill	Observed animal contamination (no analyses).
9. Moore's Creek 2 miles north of Ennis to Ennis Lake.	Observed animal contamination (no analyses).

The Yellowstone-Tongue 208 Project has concluded that with the exceptions of localized problems, it is not possible to conclusively prove that the waters of the project area are not already in compliance with the 1983 goals of the Clean Water Act Amendments. Although by some standards the Powder

River and many of the small tributaries to the Tongue and Yellowstone Rivers do not meet the goal of fishable and swimmable waters, the clause "...wherever attainable" provides adequate relief from the strict interpretation of the goals. It is apparent (but not documentable in a statistically valid fashion) that the quality of the waters, with the above mentioned exceptions, are as good or better than they were prior to the intrusion of the white settlers.

A reconnaissance level water quality study in the Flathead 208 project area revealed that Mission, Post, and Crow creeks have the most polluted water in the drainage. Fecal coliform levels from agricultural activities were found to exceed state standards at 17 of the 23 sampling stations on these streams. Because of these high coliform levels, these streams are presumed to be "not swimmable." Furthermore, dissolved oxygen levels exceeded state standards at 2 of the 13 stations on Crow Creek. Nutrient values (TSIN and TP) exceeded the recommended instream limits for preventing nuisance algal growths on both Crow and Post creeks. Extensive algal blooms have been observed on lower Crow Reservoir.

In addition to the waters cited above as not meeting the 1983 goals, a number of additional stream segments may be affected by municipal and industrial discharges to the point of excluding fishing and swimming. The reader is referred to Chapter III.B.4. Point Source Inventory and Chapter IV.F. Special Water Quality Problems--Ammonia.

B. Controls

1. Present

Table 56 is a history of federal and state expenditures as reported by official financial status reports (FSR) and the proposed FY 1980 budget. As noted, there was a steady increase in both 106 and state general funds until after FY 1976 where some leveling occurred. Generally, it has been difficult to detect additional trends since that year because of the changes in accounting and the use of carry-over and supplemental funds. Possibly the best overall indication of trends in the program is the growth of staff. In FY 1971, only four employees worked in water pollution control, whereas approximately 36 staff years are committed in the FY 1980 Montana/EPA Agreement.

2. Problems

The Executive and Legislative Branch of State Government had been supportive of water pollution control activities until the 1979 legislative session. It was during this session that funding authority for the Statewide 208 and State Hazardous Waste programs was in jeopardy of not being granted. In addition, full funding authority for 205(g) was not passed ($3,000 short). As the legislative session drew to a close, all funding authorities were reenstated due to the convincing testimony of Department of Health and Environmental Sciences Program Managers and other concerned parties.

The object lesson that came out of the 1979 legislature was that the state environmental agencies were not going to get automatic approval for their respective programs and that many key legislative figures needed to be convinced of the importance of granting the necessary funding authorities. There is no reason to believe that subsequent legislatures will not be of the same temperament.

Although inflation has definitely had an impact, the funding levels have been adequate to address the state's major priorities. As indicated in Table 56, however, the amount of state general funds used as match has remained static for the past several years creating a dependency on federal funds. The Table does not reflect Section 208 funding support which involves $51,800 of state resources and approximately $200,250 of federal funds and 7.5 staff years of effort for FY 1980.

Changes in federal funding levels will significantly affect the state staffing levels. With the fiscally conservative legislature, relief of any federal short fall would be difficult with the possibility occurring that many delegated activities might be returned to EPA.

3. Recommendations

If funding continues at the existing levels for the next several years with the current inflation rate several changes would need to be made.

TABLE 56

History of federal and state expenditures on "106" water pollution control programs

Source	FSR*	FSR	FSR	FSR	FSR	FSR	FSR	FSR	FSR	PROPOSED
	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76 + Tr Qtr.	FY 77	FY 78	FY 79	FY 80-81
Federal Dollars	$39,417	$ 59,250	$110,200	$299,110	$330,842	$415,144	$290,818	$440,106	$462,024	$334,000
% of total	40%	26%	33%	52%	61%	61%	61%	86%	87%	82%
State Dollars	$59,783	$169,681	$209,194	$275,192	$212,374	$261,390	$184,615	$ 72,000	$ 71,490	$ 72,000
% of total	60%	74%	67%	48%	39%	39%	39%	14%	13%	18%
TOTAL	$99,200	$228,931	$310,394	$574,302	$543,216	$676,534	$475,433	$512,106	$533,574	$406,000

*Financial Status Report

1. In the 208 program, the state would entertain the idea that the statewide effort would be a priority planning effort and recommend a reduction in areawide funding similar to what was experienced in FY 1980.

2. The planning coordinator with other state agencies such as Department of Natural Resources and Conservation and Department of Fish, Wildlife and Parks could not be supported with grant funds, thus delaying implementation.

3. Fixed station ambient monitoring would need to be curtailed and problem oriented intensive surveys be reduced substantially.

4. Major equipment purchases would be made only to replace essential items.

5. Administrative travel would have to be kept to a minimum.

6. On-site inspections and compliance monitoring would be made only on major permittees not meeting or suspected of not meeting permit requirements.

VI. Costs and Benefits

It is not presently possible to attempt to provide an accurate assessment of costs and benefits of meeting the goals of the Clean Water Act. This is due in part to lack of detailed comprehensive knowledge regarding current water quality improvement needs and also to lack of accurate cost data to make improvements where needed. In spite of these uncertainties, enough general information is available in selected areas to give a rough indication of the costs required to correct certain identified nonpoint source pollution problems.

It has been estimated (Montana Water Quality Management Five-Year Needs Assessment, January, 1980) that in FY 1981 approximately $600,000 will be needed in Montana to adequately develop general and site-specific control programs for all types of nonpoint source pollution problems. This figure could rise to approximately $950,000 in FY 1982 and $1,250,000 in FY 1983 if all identified needs were to be addressed. It should be emphasized that these costs do not include construction or other costs associated with actual on-the-ground implementation.

In order to provide a rough idea of the type and magnitude of costs associated with actual control of agricultural related nonpoint source problems (Montana's number one problem area), Table 57 is presented to illustrate cost estimates by 5 year periods for providing the indicated land treatments in Carbon County, Montana. The estimated 20 year total cost is approximately $9,400,000. Table 58 summarizes the same type of 20 year costs for the five counties in the Mid Yellowstone 208 area. The estimated cost is slightly over $37 million. These costs reflect complete treatment of all identified agricultural problems, which treatment would probably provide diminishing returns in water quality improvement once the most significant problems most directly impacting receiving streams have been addressed.

The Upper Missouri River Basin Level B Study recently issued a preliminary report indicating the projected costs needed to provide adequate land and water conservation practices in the study area (83,200 square miles). Using a straight line projection from present treatment costs (1975) to the years 1990 and 2000 results in the additional treated acreage and costs shown in Table 59.

For illustrative purposes data is also presented below regarding estimated costs for developing several recommended control features of the Muddy Creek project. The three features which may provide the best water quality improvement include the following: 1) on-farm irrigation management ($8.2 million); 2) supply canal relief ($3.3 million); and 3) channel stabilization and rehabilitation ($3.3 million). The total of these very rough preliminary cost estimates is $14.8 million.

The Forest Service has also provided some fairly general cost information showing expenditures for water quality improvements in Montana in 1978 and

TABLE 57

ESTIMATED COSTS FOR CONTROL OF AGRICULTURE RELATED NONPOINT SOURCE PROBLEMS IN CARBON COUNTY, MONTANA

Land Use and Candidate Treatment	Estimated Total Cost	0 - 5 Yrs.	5 - 10 Yrs.	10- 15 Yrs.	15 - 2(
Irrigated Cropland					
348 - Dam, Diversion	1,190,000	148,750	297,500	297,500	446,2
410 - Irrig. Water Return Flow (system of grade stabil. strs.)	1,282,500	320,625	320,625	320,625	320,6
432 - Irrig. Water Delivery (Irrig. pipelines)	302,000	75,500	113,250	113,250	---
449 - Irrig. Water Mgt.	---	---	---	---	---
464 - Irrig. Land Leveling	1,823,000	455,750	455,750	455,750	455,7
510 - Pasture & Hayland Mgt.	---	---	---	---	---
587 - Structure for Water Control	227,850	56,963	56,963	56,962	56,9
Dry Cropland					
344 B - Crop Residue Mgt. (stubble mulching)	---	---	---	---	--
412 - Grassed Waterway or Outlet	314,900	104,967	104,967	104,966	--
550 - Range Seeding (for contour buffers or land use change)	57,600	7,200	14,400	21,600	14,4
585 - Contour Strip Cropping	19,450	2,431	4,863	7,294	4,8
585 B - Field Strip Cropping	37,600	9,400	18,800	9,400	--
585 C - Wind Strip Cropping	19,200	4,800	9,600	4,800	--
Forest					
352 - Deferred Grazing	5,700	713	2,138	2,137	7
382 - Fencing	8,250	4,125	2,063	2,062	--
574 - Spring Development	2,850	713	713	712	7

ESTIMATED COSTS FOR CONTROL OF AGRICULTURE RELATED NONPOINT SOURCE PROBLEMS IN CARBON COUNTY, MONTANA

TABLE 57 (Continued)

Land Use and Candidate Treatment	Estimated Total Cost	0 - 5 Yrs.	5 - 10 Yrs.	10 - 15 Yrs.	15 - 2
Rangeland					
350 - Debris Basin (Sediment Retention Dam)	76,200	12,700	25,400	25,400	12,7
352 - Deferred Grazing	291,850	36,481	109,444	109,444	36,4
378 - Farm Pond (Pond)	168,450	28,075	56,150	56,150	28,0
382 - Fencing	390,100	195,050	97,525	97,525	---
550 - Range Seeding	8,000	4,000	4,000	---	---
574 - Spring Development	46,950	11,738	11,738	11,737	11,7
642a- Livestock Well	265,700	44,283	88,567	88,567	44,2
Streambank Protection					
326 - Clearing & Snagging	25,600	19,200	6,400	---	---
382 - Fencing	75,450	37,725	18,863	18,862	---
580 - Streambank Protect. (Rock Rip Rap)	2,753,950	688,488	688,488	688,487	688,4
Total ----	9,393,150	2,269,677	2,508,207	2,493,230	2,122,0

ESTIMATED COSTS FOR CONTROL OF AGRICULTURE RELATED NONPOINT SOURCE PROBLEMS
IN THE FIVE COUNTIES OF THE MID-YELLOWSTONE 208 AREA

Counties	Dry Cropland	Irrigated Cropland	Rangeland	Streambank Protection	Totals
Big Horn					
Acres (affected)	58,140	28,010	810,442		896,592
Cost in dollars	393,100	1,020,100	853,150	950,400	3,216,750
Cost ($)/Acre	6.76	36.42	1.05		
Carbon					
Acres (affected)	66,450	105,690	641,460		813,600
Cost in dollars	448,750	4,825,350	1,247,250	2,855,000	9,376,350
Cost ($)/Acre	6.75	45.66	1.94		
Stillwater					
Acres (affected)	159,050	25,150	457,353		641,553
Cost in dollars	1,484,200	3,627,150	794,550	2,345,000	8,250,900
Cost ($)/Acre	9.33	144.22	1.74		
Sweet Grass					
Acres (affected)	35,345	23,260	539,958		598,563
Cost in dollars	164,050	795,850	1,016,800	452,050	2,428,750
Cost ($)/Acre	4.64	34.21	1.88		
Yellowstone					
Acres (affected)	119,840	111,980	855,350		967,170
Cost in dollars	857,580	3,750,350	669,620	8,751,000	14,028,550
Cost ($)/Acre	7.16	33.49	0.78		
TOTAL COSTS	3,347,680	14,018,800	4,581,370	15,353,450	37,301,300

Table 59

ESTIMATED COSTS [a/] TO PROVIDE ADEQUATE LAND AND WATER CONSERVATION PRACTICES IN THE UPPER MISSOURI LEVEL B STUDY AREA.

Land Use and Ownership	Adequately Treated--1975	Future Treatment [b/]	
		1990	2000
	(1,000 acres)	(1,000 acres)	
Irrigated Crop and Pasture	532	797 (59,416)	945 (92,599)
Dryland Crop	6,819	8,382 (12,332)	9,531 (21,398)
Range and Dry Pasture			
(Nonfederal)	11,995	13,649 (40,573)	15,028 (74,399)
(Forest Service)	1,328	1,372 (2,440)	1,379 (4,000)
(BLM)	1,574	3,748 (33,175)	4,370 (42,667)
Commercial Forest			
(Nonfederal)	713	714 (176)	714 (292)
(Forest Service)	2,042	2,132 (116)	2,133 (236)
(BLM)	133	215 (831)	287 (1,560)
Noncommercial Forest			
(Nonfederal)	373	373 (60)	373 (120)
(Forest Service)	2,497	2,498 (116)	2,500 (176)
(BLM)	137	212 (898)	248 (1,330)
Other Lands	253	379 (3,087)	428 (4,288)

a/ Additional total investment costs required to bring treatment from current level (1975) to level indicated are shown in thousands of dollars in parentheses.

b/ Future treatment levels are based on straight-line projections from historical rates of treatment.

1979 (see Table 60). The total costs were $138,740 in 1978 and $180,162 in 1979. There is no data presently available to accurately estimate the total funds required to adequately address the most significant forestry nonpoint source problems.

Point sources of pollution in Montana are effectively controlled under the Construction Grant and Waste Discharge Permit Programs. The Preliminary Draft Statewide 208 report (November, 1978) indicated that less than 100 stream miles were degraded by point source pollution and these problems were expected to be easily eliminated by 1983. This will be accomplished primarily through planned expenditure of approximately $82 million federal dollars by the Montana Construction Grants Program through FY 1983.

TABLE 60

National Forests - Montana

Expenditures for Water Quality Improvement
1978 & 1979

National Forest	Year	Total	% Expenditures by Cause of Problem						
			Road Related	Mining	Irrigation	Logging	Recreation	Off Road Vehicle Travel	Grazin
BEAVERHEAD	1978	$1,000	100	0	0	0	0	0	0
	1979	11,800	20	60	20	0	0	0	0
BITTERROOT	1978	11,000	10	0	0	30	10	50	0
	1979	9,000	5	0	0	5	70	20	0
CUSTER	1978	2,500	100	0	0	0	0	0	0
	1979	7,000	25	0	0	0	0	0	75
DEERLODGE	1978	3,000	0	0	0	0	0	0	100
	1979	0	0	0	0	0	0	0	0
FLATHEAD	1978	0	0	0	0	0	0	0	0
	1979	0	0	0	0	0	0	0	0
HELENA	1978	9,740	100	0	0	0	0	0	0
	1979	7,662	100	0	0	0	0	0	0
GALLATIN	1978	2,800	0	100	0	0	0	0	0
	1979	7,500	66	0	0	33	0	0	0
KOOTENAI	1978	108,700	30	0	0	70	0	0	0
	1979	120,500	30	0	0	70	0	0	0
LEWIS & CLARK	1978	0*	0	0	0	0	0	0	0
	1979	15,000*	90	0	0	10	0	0	0
LOLO	1978	0	0	0	0	0	0	0	0
	1979	1,700	0	0	0	90	0	10	0
TOTAL	1978	138,740							
	1979	180,162							

*Excludes $643,000 expenditure for the correction of water quality and flood hazards caused by 1975 flood.

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Appendix A U.S.G.S. WATER QUALITY STATIONS - MONTANA 1980 WATER YEAR

STATION NUMBER	STATION NAME	Office	Chem	Sed	Nutr	Biol	Micro	Sup
05020500	St Mary River at international boundary	H	7	7	0	7	0	NASQAN
06018500	Beaverhead River near Twin Bridges	H	7		0		0	MFS
06023000	Ruby River near Twin Bridges	H			9			F/G
06024580	Big Hole River near Wise River	H			9			F/G
06025500	Big Hole River near Melrose	H			9			F/G
06026400	Big Hole River near Twin Bridges	H			9			F/G
06036650	Jefferson River near Three Forks	H			9			F/G
06041000	Madison River below Ennis Lake, near McAllister	H			9			F/G
06052500	Gallatin River at Logan	H			9			F/G
06054500	Missouri River at Toston	H	7	7	9	7	0	NASQAN
06058502	Missouri River below Canyon Ferry Dam, near Helena	H	7		0		0	MFS
06080900	Sun River below diversion dam, near Augusta	H					7	MFS
06088300	Muddy Creek near Vaughn	H	7	0	0		0	MFS
06088500	Muddy Creek at Vaughn	H	7	0	0		0	MFS
06089000	Sun River near Vaughn	H	7		0		0	MFS
06090500	Belt Creek near Monarch	H			9			F/G
06092000	Two Medicine River near Browning	H					7	MFS
06093200	Badger Creek below Four Horns Canal, near Browning	H					7	MFS
06098100	Birch Creek near Valier	H	7		0		0	MFS
06099500	Marias River near Shelby	H					7	MFS
06101500	Marias River near Chester	H	7	7	0	7	0	NASQAN
06109500	Missouri River at Virgelle	H	7	7	9	7	0	NASQAN
06115200	MIssouri River near Landusky	B	7	0	0	7	0	NAS/COR
06126450	Rehder Creek near Klein	B	7	7	7		7	BLM
06126470	Half Breek Creek near Klein	B	7	7	7		7	BLM
06126500	Musselshell River near Roundup	B	7	7	7		7	BLM
06127150	East Parrot Creek near Roundup	B	7	7	7		7	BLM
06127160	West Parrot Creek near Roundup	B	7	7	7		7	BLM
06127300	Fattig Creek near Delphia	B	7	7	7		7	BLM
06130500	Musselshell River at Mosby	B	7	7	0	7	0	NASQAN
06130935	Crow Rock Creek near Cohagen	C	6	6	6	6	6	USGS
06132000	Missouri River below Fort Peck Dam	F	7	7	0	7	0	NASQAN
06137570	Boxelder Creek near Rocky Boy	H	5	5	5		5	MFS
06145500	Lodge Creek below McRae Creek at inter. boundary	H	8					IJC
06154400	Peoples Creek near Hays	F					7	MFS
06154410	Little Peoples Creek near Hays	F	5	5	5		5	MFS
06156000	Whitewater Creek near international boundary	H	8					IJC
06164510	Milk River at Juneburg Bridge near Saco	F	7		0		0	MFS
06166000	Beaver Creek below Guston Coulee, near Saco	F	8		8			MFS
06169500	Rock Creek below Horse Creek at inter. boundary	F	7	7	7	7	7	Bench

0 Once-daily, continuous
1 Once-daily, seasonal
2 Twice-daily, continuous
3 Weekly
4 Semi-monthly
5 Quarterly
6 Monthly-seasonal
7 Monthly
8 Miscellaneous
9 Continuous records

Appendix A U.S.G.S. WATER QUALITY STATIONS - MONTANA 1980 WATER YEAR

STATION NUMBER	STATION NAME	Office	Chem	Sed	Level	Biol	Prec	Agency
05020500	St Mary River at international boundary	H	7	7	0	7	0	NASQAN
06018500	Beaverhead River near Twin Bridges	H	7		0		0	MFS
06023000	Ruby River near Twin Bridges	H			9			F/G
06024580	Big Hole River near Wise River	H			9			F/G
06025500	Big Hole River near Melrose	H			9			F/G
06026400	Big Hole River near Twin Bridges	H			9			F/G
06036650	Jefferson River near Three Forks	H			9			F/G
06041000	Madison River below Ennis Lake, near McAllister	H			9			F/G
06052500	Gallatin River at Logan	H			9			F/G
06054500	Missouri River at Toston	H	7	7	9	7	0	NASQAN
06058502	Missouri River below Canyon Ferry Dam, near Helena	H	7		0		0	MFS
06080900	Sun River below diversion dam, near Augusta	H					7	MFS
06088300	Muddy Creek near Vaughn	H	7	0	0		0	MFS
06088500	Muddy Creek at Vaughn	H	7	0	0		0	MFS
06089000	Sun River near Vaughn	H	7		0		0	MFS
06090500	Belt Creek near Monarch	H			9			F/G
06092000	Two Medicine River near Browning	H					7	MFS
06093200	Badger Creek below Four Horns Canal, near Browning	H					7	MFS
06098100	Birch Creek near Valier	H	7		0		0	MFS
06099500	Marias River near Shelby	H					7	MFS
06101500	Marias River near Chester	H	7	7	0	7	0	NASQAN
06109500	Missouri River at Virgelle	H	7	7	9	7	0	NASQAN
06115200	MIssouri River near Landusky	B	7	0	0	7	0	NAS/COR
06126450	Rehder Creek near Klein	B	7	7	7		7	BLM
06126470	Half Breek Creek near Klein	B	7	7	7		7	BLM
06126500	Musselshell River near Roundup	B	7	7	7		7	BLM
06127150	East Parrot Creek near Roundup	B	7	7	7		7	BLM
06127160	West Parrot Creek near Roundup	B	7	7	7		7	BLM
06127300	Fattig Creek near Delphia	B	7	7	7		7	BLM
06130500	Musselshell River at Mosby	B	7	7	0	7	0	NASQAN
06130935	Crow Rock Creek near Cohagen	C	6	6	6	6	6	USGS
06132000	Missouri River below Fort Peck Dam	F	7	7	0	7	0	NASQAN
06137570	Boxelder Creek near Rocky Boy	H	5	5	5		5	MFS
06145500	Lodge Creek below McRae Creek at inter. boundary	H	8					IJC
06154400	Peoples Creek near Hays	F					7	MFS
06154410	Little Peoples Creek near Hays	F	5	5	5		5	MFS
06156000	Whitewater Creek near international boundary	H	8					IJC
06164510	Milk River at Juneburg Bridge near Saco	F	7		0		0	MFS
06166000	Beaver Creek below Guston Coulee, near Saco	F	8		8			MFS
06169500	Rock Creek below Horse Creek at inter. boundary	F	7	7	7	7	7	Bench

0 Once-daily, continuous
1 Once-daily, seasonal
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3 Weekly
4 Semi-monthly
5 Quarterly
6 Monthly-seasonal
7 Monthly
8 Miscellaneous
9 Continuous records

WATER QUALITY STATIONS - MONTANA 1980 WATER YEAR

STATION NUMBER	STATION NAME	Office	Chem	Sed	Temp	Biol	Spec Cond	Coop
06170000	McEachern Creek at international boundary	F	8					IJC
06174000	Willow Creek near Glasgow	F					7	MFS
06174500	Milk River at Nashua	F	7	7	0	7	0	NASAN
06177000	Missouri River near Wolf Point	F			9			F/G
06177500	Redwater River at Circle	F	7	7	7		7	MFS
06177825	Redwater River near Vida	F	7	7	7		7	MFS
06178000	Poplar River at international boundary	F	7	7	7		7	EPA
06178500	East Poplar River at international boundary	F	7	7	9	5	7	IJC
06179000	East Fork Poplar River near Scobey	F	7	7	7		7	EPA
06179200	Poplar River above West Fork, near Bredette	F	7	7	7		7	EPA
06180400	West Fork Poplar River near Bredette	F	7	7	7		7	EPA
06181000	Poplar River near Poplar	F	7	7	7		7	EPA
06181995	Beaver Creek at international boundary	F	5	5	5		5	
06183450	Big Muddy Creek near Antelope	F	7	7	7		7	MFS
06185500	Missouri River near Culbertson	F	7	7	0	7	0	NASQAN
06191500	Yellowstone River at Corwin Springs	B			9			F/G
06192500	Yellowstone River near Livingston	B	7	7	9	7	0	NASQAN
06207500	Clarks Fork Yellowstone River near Belfry	B	7		7		7	WY
06207510	Big Sand Coulee at Wyoming-Montana state line	B	5	1	1		5	WY
06208800	Clarks Fork Yellowstone River near Silesia	B			9			F/G
06214500	Yellowstone River at Billings	B	7	0	0	7	0	NASQAN
06216000	Pryor Creek at Pryor	B					7	MFS
06216900	Pryor Creek near Huntley	B					7	MFS
06217500	Yellowstone River at Huntley	B	7	7	7	7	7	EPA
06217750	Fly Creek at Pompeys Pillar	B	7		0		0	MFS
06287000	Bighorn River near St. Xavier	B	7		0		0	MFS
06289000	Little Bighorn at state line, near Wyola	B					7	MFS
06290500	Little Bighorn River below Pass Creek, near Wyola	B					7	MFS
06291000	Owl Creek near Lodge Grass	B					7	MFS
06294700	Bighorn River at Bighorn	B	7	7	9	7	0	NASQAN
06294940	Sarpy Creek near Hysham	B	7	7	7		7	BLM
06294980	East Fork Armells Creek near Colstrip	B	7	7	7		7	BLM
06294995	Armells Creek near Forsyth	B	7	7	7		7	BLM
06295000	Yellowstone River at Forsyth	B	7	0	7		7	EPA
06295113	Rosebud Creek at reservation boundary, near Kirby	B	7	7	7		7	BLM
06295250	Rosebud Creek near Colstrip	B	7	7	7		7	BLM
06295380	Cow Creek near Colstrip	B	7	7	7		7	BLM
06295420	Snider Creek near Brandenberg	B	7	7	7		7	BLM
06296003	Rosebud Creek at mouth, near Rosebud	B	7	7	0		0	BLM
06296120	Yellowstone River near Miles City	B	7	7	0		0	MFS

0 Once-daily, continuous
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8 Miscellaneous
9 Continuous records

WATER QUALITY STATIONS - MONTANA 1980 WATER YEAR

STATION NUMBER	STATION NAME							
06306100	Squirrel Creek near Decker	B	7	7	7		7	BLM
06306300	Tongue River @ state line near Decker	B	7		7		7	WY
06306900	Spring Creek near Decker	B	7	7	7		7	BLM
06307500	Tongue River @ Tongue River dam, near Decker	B	7	7	7		7	BLM
06307528	Prairie Dog Creek near Birney	B	7	7	7		7	MFS
06307540	Hanging Woman Creek at state line, near Otter	B	7	7	7		7	BLM
06307545	Waddle Creek near Otter	B	7	7	7		7	BLM
06307550	Trail Creek near Otter	B	7	7	7		7	BLM
06307560	East Trail Creek near Otter	B	7	7	7		7	BLM
06307563	Corral Creek near Otter	B	7	7	7		7	BLM
06307567	Horse Creek near Birney	B	7	7	7		7	BLM
06307570	Hanging Woman Creek below Horse Creek, near Birney	B	7	7	7		7	BLM
06307600	Hanging Woman Creek near Birney	B	7	7	7		7	BLM
06307616	Tongue River at Birney Day School Bridge, near Birney	B	7	7	7		7	EPA
06307665	Otter Creek near Otter	B	7	7	7		7	BLM
06307717	Otter Creek below Fifteenmile Creek, near Otter	B	7	7	7		7	BLM
06307735	Home Creek near Ashland	B	7	7	7		7	BLM
06307740	Otter Creek at Ashland	B	7	7	7		7	BLM
06307830	Tongue River below Brandenberg Bridge, near Ashland	B	7	0	0		7	BLM
06308400	Pumpkin Creek near Miles City	B	7	7	7		7	BLM
06308500	Tongue River at Miles City	B	7	0	9	7	0	NASQAN
06309000	Yellowstone River at Miles City	B			9			F/G
06309079	Muster Creek near Kinsey	C	6	6	6	6	6	USGS
06309145	Custer Creek near Kinsey	C	6	6	6	6	6	USGS
06326300	Mizpah Creek near Mizpah	B	7	7	7		7	BLM
06326500	Powder River near Locate	B	7	0	0	7	0	NASQAN
06326507	Locate Creek near Ismay	B	7	7	7		7	BLM
06326520	Powder River at mouth, near Terry	B			9			F/G
06326530	Yellowstone River near Terry	B	7	7	7		7	EPA
06326555	Cherry Creek near Terry	B	7	7	7		7	BLM
06326600	O'Fallon Creek near Ismay	C	7	7	7	7	7	USGS
06326953	Clear Creek near HOyt	C	6	6	6	6	6	USGS
06326995	Upper Sevenmile Creek near Lindsay	C	6	6	6	6	6	USGS
96327850	Glendive Creek near Glendive	F	7	7	7		7	BLM
06328000	Deer Creek near Glendive	C	6	6	6	6	6	USGS
06329000	Cottonwood Creek near Intake	F	7	7	7		7	BLM
06329500	Yellowstone River near Sidney	F	7	0	9	7	0	COR/NA
06336500	Beaver Creek at Wibaux	F	7	7	7		7	MFS

0 Once-daily, continuous
1 Once-daily, seasonal
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7 Monthly
8 Miscellaneous
9 Continuous records

WATER QUALITY STATIONS - MONTANA 1980 WATER YEAR

STATION NUMBER	STATION NAME	Office	Chem	Sed	Temp	Biol	Spec Cond	Oper
06170000	McEachern Creek at international boundary	F	8					IJC
06174000	Willow Creek near Glasgow	F					7	MFS
06174500	Milk River at Nashua	F	7	7	0	7	0	NASAN
06177000	Missouri River near Wolf Point	F			9			F/G
06177500	Redwater River at Circle	F	7	7	7		7	MFS
06177825	Redwater River near Vida	F	7	7	7		7	MFS
06178000	Poplar River at international boundary	F	7	7	7		7	EPA
06178500	East Poplar River at international boundary	F	7	7	9	5	7	IJC
06179000	East Fork Poplar River near Scobey	F	7	7	7		7	EPA
06179200	Poplar River above West Fork, near Bredette	F	7	7	7		7	EPA
06180400	West Fork Poplar River near Bredette	F	7	7	7		7	EPA
06181000	Poplar River near Poplar	F	7	7	7		7	EPA
06181995	Beaver Creek at international boundary	F	5	5	5		5	
06183450	Big Muddy Creek near Antelope	F	7	7	7		7	MFS
06185500	Missouri River near Culbertson	F	7	7	0	7	0	NASQAN
06191500	Yellowstone River at Corwin Springs	B			9			F/G
06192500	Yellowstone River near Livingston	B	7	7	9	7	0	NASQAN
06207500	Clarks Fork Yellowstone River near Belfry	B	7		7		7	WY
06207510	Big Sand Coulee at Wyoming-Montana state line	B	5	1	1		5	WY
06208800	Clarks Fork Yellowstone River near Silesia	B			9			F/G
06214500	Yellowstone River at Billings	B	7	0	0	7	0	NASQAN
06216000	Pryor Creek at Pryor	B					7	MFS
06216900	Pryor Creek near Huntley	B					7	MFS
06217500	Yellowstone River at Huntley	B	7	7	7	7	7	EPA
06217750	Fly Creek at Pompeys Pillar	B	7		0		0	MFS
06287000	Bighorn River near St. Xavier	B	7		0		0	MFS
06289000	Little Bighorn at state line, near Wyola	B					7	MFS
06290500	Little Bighorn River below Pass Creek, near Wyola	B					7	MFS
06291000	Owl Creek near Lodge Grass	B					7	MFS
06294700	Bighorn River at Bighorn	B	7	7	9	7	0	NASQAN
06294940	Sarpy Creek near Hysham	B	7	7	7		7	BLM
06294980	East Fork Armells Creek near Colstrip	B	7	7	7		7	BLM
06294995	Armells Creek near Forsyth	B	7	7	7		7	BLM
06295000	Yellowstone River at Forsyth	B	7	0	7		7	EPA
06295113	Rosebud Creek at reservation boundary, near Kirby	B	7	7	7		7	BLM
06295250	Rosebud Creek near Colstrip	B	7	7	7		7	BLM
06295380	Cow Creek near Colstrip	B	7	7	7		7	BLM
06295420	Snider Creek near Brandenberg	B	7	7	7		7	BLM
06296003	Rosebud Creek at mouth, near Rosebud	B	7	7	0		0	BLM
06296120	Yellowstone River near Miles City	B	7	7	0		0	MFS

0 Once-daily, continuous
1 Once-daily, seasonal
2 Twice-daily, continuous
3 Weekly
4 Semi-monthly
5 Quarterly
6 Monthly-seasonal
7 Monthly
8 Miscellaneous
9 Continuous records

WATER QUALITY STATIONS - MONTANA 1980 WATER YEAR

STATION NUMBER	STATION NAME	Class	Chem	Bact	Sed	Biol	Aq Life	Org
06306100	Squirrel Creek near Decker	B	7	7	7		7	BLM
06306300	Tongue River @ state line near Decker	B	7		7		7	WY
06306900	Spring Creek near Decker	B	7	7	7		7	BLM
06307500	Tongue River @ Tongue River dam, near Decker	B	7	7	7		7	BLM
06307528	Prairie Dog Creek near Birney	B	7	7	7		7	MFS
06307540	Hanging Woman Creek at state line, near Otter	B	7	7	7		7	BLM
06307545	Waddle Creek near Otter	B	7	7	7		7	BLM
06307550	Trail Creek near Otter	B	7	7	7		7	BLM
06307560	East Trail Creek near Otter	B	7	7	7		7	BLM
06307563	Corral Creek near Otter	B	7	7	7		7	BLM
06307567	Horse Creek near Birney	B	7	7	7		7	BLM
06307570	Hanging Woman Creek below Horse Creek, near Birney	B	7	7	7		7	BLM
06307600	Hanging Woman Creek near Birney	B	7	7	7		7	BLM
06307616	Tongue River at Birney Day School Bridge, near Birney	B	7	7	7		7	EPA
06307665	Otter Creek near Otter	B	7	7	7		7	BLM
06307717	Otter Creek below Fifteenmile Creek, near Otter	B	7	7	7		7	BLM
06307735	Home Creek near Ashland	B	7	7	7		7	BLM
06307740	Otter Creek at Ashland	B	7	7	7		7	BLM
06307830	Tongue River below Brandenberg Bridge, near Ashland	B	7	0	0		7	BLM
06308400	Pumpkin Creek near Miles City	B	7	7	7		7	BLM
06308500	Tongue River at Miles City	B	7	0	9	7	0	NASQAN
06309000	Yellowstone River at Miles City	B			9			F/G
06309079	Muster Creek near Kinsey	C	6	6	6	6	6	USGS
06309145	Custer Creek near Kinsey	C	6	6	6	6	6	USGS
06326300	Mizpah Creek near Mizpah	B	7	7	7		7	BLM
06326500	Powder River near Locate	B	7	0	0	7	0	NASQAN
06326507	Locate Creek near Ismay	B	7	7	7		7	BLM
06326520	Powder River at mouth, near Terry	B			9			F/G
06326530	Yellowstone River near Terry	B	7	7	7		7	EPA
06326555	Cherry Creek near Terry	B	7	7	7		7	BLM
06326600	O'Fallon Creek near Ismay	C	7	7	7	7	7	USGS
06326953	Clear Creek near HOyt	C	6	6	6	6	6	USGS
06326995	Upper Sevenmile Creek near Lindsay	C	6	6	6	6	6	USGS
96327850	Glendive Creek near Glendive	F	7	7	7		7	BLM
06328000	Deer Creek near Glendive	C	6	6	6	6	6	USGS
06329000	Cottonwood Creek near Intake	F	7	7	7		7	BLM
06329500	Yellowstone River near Sidney	F	7	0	9	7	0	COR/NA
06336500	Beaver Creek at Wibaux	F	7	7	7		7	MFS

0 Once-daily, continuous
1 Once-daily, seasonal
2 Twice-daily, continuous
3 Weekly
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5 Quarterly
6 Monthly-seasonal
7 Monthly
8 Miscellaneous
9 Continuous records

WATER QUALITY STATIONS - MONTANA 1980 WATER YEAR

STATION NUMBER	STATION NAME	Chem	Sed	Cont	Temp	Biol	Spec	Coop
12300110	Lake Koocanusa at international boundary	K	4		4	4	4	CORP
12301300	Tobacco River near Eureka	K			9			CORP
12301830	Lake Koocanusa at Tenmile Creek near Libby	K	4		4	4	4	CORP
12301919	Lake Koocanusa at Forebay near Libby	K	4		4	4	4	CORP
12301933	Kootenai River below Libby dam, near Libby	K	4		4		4	CORP
12302055	Fisher River near Libby	K			9			CORP
12304500	Yaak River near Troy	K			9			CORP
12324200	Clark Fork at Deerlodge	H			9			F/G
12331900	Clark Fork near Clinton	H			9			F/G
12334510	Rock Creek near Clinton	H			9			F/G
12340500	Clark Fork above Missoula	K			9			F/G
12353000	Clark Fork below Missoula	K	7	7	9	7	0	NASQAN
12355000	Flathead River at Flathead, British Columbia	K	7	7	9	7	0	NASQAN
12355500	North Fork Flathead River near Columbia Falls	K			9			F/G
12362500	South Fork Flathead River near Columbia Falls	K			9			F/G
12363000	Flathead River at Columbia Falls	K	7	7	9	7	0	NASQAN
12365000	Stillwater River near Whitefish	K			9			F/G
12365800	Swift Creek near Whitefish	K			9			F/G
12366000	Whitefish River near Kalispell	K			9			F/G
12372000	Flathead River near Polson	K			9			F/G
455936108102200	Huntley Project Drain #7 near Worden	B	7		7		7	MF
482250107391001	Lake Bowdoin near Malta	F	8		8			MFS

0	Once-daily	5	Quarterly
1	Once-daily, seasonal	6	Monthly-seasonal
2	Twice-daily, continuous	7	Monthly
3	Weekly	8	Miscellaneous
4	Semi-monthly	9	Continuous records

	*Park Lake	H	5		5		5	St.H
	*Holland Lake	H	5		5		5	St.H
06040300	*Jack Creek near Ennis	H	7	7	7		7	St.H
06077000	*Sheep Creek near White Suphur Springs	H	7	7	7		7	St.H
12335500	*Nevada Creek above reservoir, near Finn	H	7	7	7		7	St.H
12346500	*Skalkaho Creek near Hamilton	H	7	7	7		7	St.H
12355350	*Big Creek at Big Creek Ranger Station, near Columbia Falls	K	7	7	7		7	St.H

* Stations set up to monitor the water quality impacts associated with ash fallout from the Mount St. Helens volcanic eruption.

Appendix B. U.S.G.S. Hydrologic Units Included in State of Montana Water Quality Management Planning Basins

Montana Water Quality Management Planning Basins	Old U.S.G.S. Basin Subdivisions	New U.S.G.S. Cataloging Units	Major Stream Segments
St. Mary	40T	10010001	Belly
		10010002	St. Mary
Upper Missouri Tributaries	41A	10020001	Red Rock
	41B	10020002	Beaverhead
	41C	10020003	Ruby
	41D	10020004	Big Hole
	41G	10020005	Jefferson
	41E	10020006	Boulder
	41F	10020007	Madison
	41H	10020008	Gallatin
Missouri-Sun-Smith	41I	10030101	Upper Missouri
	41QJ	10030102	Lower Upper Missouri
	41U	"	" " "
	41Q	"	" " "
		10030105	Belt
	41J	10030103	Smith
	41K	10030104	Sun
Marias	41M	10030201	Two Medicine
	41L	10030202	Cut Bank
	41P	10030203	Marias
	41N	10030204	Willow
	41Ø	10030205	Teton
Middle Missouri	41T	10040101	Bullwhacker-Dog.
	41R	10040102	Arrow
	41S	10040103	Judith
	40EJ	10040104	Fort Peck Reservoir
	40E	"	" " "
	40D	10040105	Big Dry
		10040106	Little Dry
Musselshell	40A	10040201	Upper Musselshell
	40C	10040202	Middle Musselshell
		10040205	Lower Musselshell
	40B	10040203	Flatwillow
		10040204	Box Elder
Milk	40F	10050001	Milk Headwaters
		10050002	Upper Milk
		10050003	Wild Horse Lake
	40J	10050004	Middle Milk
		10050007	Lodge
		10050008	Battle
		10050010	Cottonwood
	40H	10050005	Big Sandy
	40G	10050006	Sage
	40I	10050009	Peoples
	40K	10050011	Whitewater

Montana Water Quality Management Planning Basins	Old U.S.G.S. Basin Subdivisions	New U.S.G.S. Cataloging Units	Major Stream Segments
Milk (continued)	40Ø	10050012	Lower Milk
		10050016	Porcupine
	40L	10050013	Frenchman
	40M	10050014	Beaver
	40N	10050015	Rock
Lower Missouri	40S	10060001	Prairie Elk-Wolf
		10060005	Charlie-Little Muddy
	40P	10060002	Redwater
	40Q	10060003	Poplar
		10060004	West Fork Poplar
	40R	10060006	Big Muddy
		10060007	Brush Lake Closed Basin
Upper Yellowstone	43B	10070001	Yellowstone Headwaters
		10070002	Upper Yellowstone
	43BJ	"	" "
	43BV	"	" "
	43A	10070003	Shields
	43QJ	10070004	Middle Upper Yellowstone
	43C	10070005	Stillwater
	43D	10070006	Clark's Fork Yellowstone
Middle Yellowstone	43Q	10070007	Lower Upper Yellowstone
	43E	10070008	Pryor
	43P	10080010	Bighorn Lake
		10080015	Lower Bighorn
	43N	10080014	Shoshone
	43Ø	10080016	Little Bighorn
	42B	10090101	Upper Tongue
	42C	10090102	Lower Tongue
	42A	10100003	Rosebud
	42KJ	10100002	Big Porcupine
		10100001	Lower Yellowstone - Sunday (excluding Sunday Cr.)
Lower Yellowstone	42K	"	Lower Yellowstone - Sunday (Sunday Cr. portion)
	42I	10090208	Little Powder
	42J	10090207	Middle Powder
		10090209	Lower Powder
		10090210	Mizpah
	42M	10100004	Lower Yellowstone
	42L	10100005	O'Fallon
Little Missouri	39F	10110201	Upper Little Missouri
	39FJ	"	" " "
	39E	10110202	Boxelder
	39H	10110203	Middle Little Missouri
	39G	10110204	Beaver
	38H	10120202	Lower Belle Fourche
Kootenai	76D	17010101	Upper Kootenai
		17010104	Lower Kootenai
	76B	17010103	Yaak
		17010105	Moyie
	76C	17010102	Fisher

Montana Water Quality Management Planning Basins	Old U.S.G.S. Basin Subdivisions	New U.S.G.S. Cataloging Units	Major Stream Segments
Upper Clark Fork	76G	17010201	Upper Clark Fork
	76E	17010202	Flint-Rock
	76GJ	"	" "
	76F	17010203	Blackfoot
Lower Clark Fork	76M	17010204	Middle Clark Fork
	76H	17010205	Bitterroot
	76L	17010212	Lower Flathead
	76N	17010213	Lower Clark Fork
Flathead	76LJ	17010206	North Fork Flathead
		17010208	Flathead Lake
		17010210	Stillwater
	76I	17010207	Middle Fork Flathead
	76J	17010209	South Fork Flathead
	76K	17010211	Swan